The second NCAA article of April 10, 2000, is titled: "NCAA Baseball Research Panel sought wood-like standard to start". NCAA Director of Research, Petr is again quoted as saying:

> "Our goal here was to make an aluminum bat hit like a wood bat under the same conditions." (Exhibit 11-Z)

There is not question that all associations, bat manufacturers and scientist understood there is a safety issue involved with high performance aluminum bats. The manufacturers have been able to quiet the associations who make the rules because Little League, Dixie Youth Baseball, Pony League, Babe Ruth League, Colt League, American Softball Association and many others are paid royalties so the association name is put on the bat used in that particular league. This amounts to substantial sums of money the associations don't want to lose. The NCAA has 200 coaches being paid by the manufacturers and ABCA receives over $100,000.00, annually for ABCA National Trophy, etc., and its association. Manufacturers sponsor clinics, trade shows, and many other activities, which the associations don't want to lose. The manufacturers get advertising and tremendous sales are generated from these endeavors so its very easy to see why associations have the off again-on again approach to regulations. CPSC is the only entity that is independent and can set the performance standards so they will be followed. Any performance over wood bats exposes the consumers to unnecessary risks of injury.

Description of Risk

Nature and Severity of the Risk of Injury

The game of baseball has been played professionally for over 125 years with wood bats. Only in the past 27 years have amateur players used nonwood bats in Little League, High School and College Competition. In 1974, the first year that aluminum bats were allowed in intercollegiate competition, the aluminum bat was a cost-effective alternative to wood bats. However, in the past 15 years, innovative design principles have fueled a performance race by bat manufacturers in an attempt to gain more and more market share. In 1974, non-wood bats cost the consumer approximately $40.00 each. The 2000 price for non-wood bats to the consumer is $250.00 to $300.00.

The aluminum bat manufacturers have developed close business relationships with the world's leading aluminum companies, which in turn have developed stronger, lighter, space-age alloys. With the advent of the C405 aluminum alloy that exploded onto the scene in 1995, safety and injury concerns came into focus and the frequency of injuries escalated. There are other new alloys that just came out in 1999.

As technological advancements in aluminum alloys have infiltrated amateur baseball fields, severe injuries to players have become more and more common. (Exhibit 1) The player most vulnerable to injury from a batted ball is the pitcher, who ends up approximately 52-53 feet from the bat-ball collision point after he follows through on his pitching delivery. Most experts agree that a pitcher needs .40 seconds to defend his position at that distance, which equates to a maximum batted-ball exit speed of 93-94 mph. (Exhibit 14) This is the high-end average speed at which a ball is hit off of a wood bat. Most experts also agree that a high-performance aluminum bat, which is used at the intercollegiate and interscholastic levels, will propel a ball at speeds of anywhere from 97-123 mph. (Exhibit 14)

The high-profile injuries to Arizona State pitcher Ryan Mills and Houston pitcher Danny Crawford, who were hit in the face by line drives off aluminum bats, revealed quite vividly how defenseless pitchers are if a line drive is hit up the middle, and were the centerpiece of broadcast reports by FOX Sports and ESPN looking into the issue of bat performance and safety. (Exhibit 27) Both news organizations expressed wonderment that meaningful bat performance standards had not been established by governing bodies, and that manufacturers had been given free reign to manufacture aluminum bats designed for the highest performance rather than wood-like performance and safety.

<u>The fact that a baseball is hit harder, and hit harder more often with high-performance aluminum bats as opposed to wood bats, leaves defensive players, namely</u>

pitchers, in a compromising and dangerous position. In a study by Dr. Joseph J. "Trey" Crisco III, entitled "Baseball Bat Performance: A Batting Cage Study," he agrees that aluminum bats clearly out-perform wood bats. (Exhibit 20) The report, in which batted-ball exit velocities were recorded using 19 players of various skill level, stated that 50 percent of the wood bat hits exceeded 87 miles per hour while only 5 percent exceeded 97 miles per hour. Conversely, 50 percent of the hits from one of the aluminum bats tested exceeded 96 miles per hour and 5 percent were greater than 106 miles per hour.

As stated in Cedric Dempsey's August 28, 1998, memo to the NCAA membership:

> "The average time to react to a ball hit from [a distance of 54 feet] is approximately .4 seconds. The ball-exit velocity that matches this reaction time is 93 miles per hour. Ball-exit velocities from aluminum bats currently in use in collegiate play have been measured from 103-113 miles per hour, translating to a reaction time of .357 to .315 seconds at a distance of 54 feet. Therefore, there is a window of time during which a collegiate baseball pitcher could be vulnerable to being struck by a batted ball." (Exhibit 14)

In the Rules Committee's memo to the NCAA membership on December 4, 1998, it stated:

> "The Committee was unanimously convinced that bat performance was indeed a safety risk to pitchers and infielders, that there has indeed been a change in the way the college game of baseball is played, and that the available evidence was more than sufficient to justify a change in the rule as soon as practically possible. There is simply no question that aluminum bats substantially outperform traditional wood bats, that the risk of injury to pitchers and infielders is real, and that a performance limit on the aluminum bats was required to bring the game of baseball closer to its traditional form." (Exhibit 16)

In addition to the NCAA's Injury Surveillance System, the NCAA collected injury data in 1998 pertaining to pitchers being struck by a batted ball. Athletic trainers at all 273 Division I schools that sponsor baseball were contacted to help quantify the frequency of pitchers impacted by a batted ball. In his August 28, 1998, memo, Mr.

Dempsey discussed this data by saying that "the frequency of pitchers impacted with a batted ball is greater than might be expected from the ISS data." In fact, he stated that "[i]t was projected that approximately 375 incidents of pitchers impacted with a batted ball occurred this past season in Division I baseball games alone." (Exhibits 14 and 28) In addition, 11% of the injuries required a physician's medical attention. (41 pitchers)

In 1995, Bud Cosgrove, chair of the American Society for Testing and Materials (ASTM) Committee F-8 on Sports Equipment and Facilities, wrote a memorandum in which he stated he was "convinced that the 'reaction-time problem' associated with the current bat and ball standards development in softball has caught the attention of all of us, and it is clearly a safety issue we cannot ignore". (Exhibit 29)

In their effort to avoid the implementation of the NCAA's ruling, two major manufacturers agreed to indemnify NCAA member institutions as to the liability risk these schools faced regarding the high-performance aluminum bats used during the 1999 season. However, this attempt to appease the NCAA failed to address the safety and welfare of the student-athlete. In essence, these companies put a price on the health and safety of the athlete. There are presently two lawsuits against Louisville Slugger as a result of these indemnifications. (Exhibit 19A) (Exhibit 20A)

Possible reasons for the existence of the risk of injury

One reason this unreasonable risk of injury has been allowed to continue is due to the continual effort on the part of the aluminum bat manufacturers to deceive the NCAA and NHSF, its member institutions, its coaches, and the public. manufacturers have fraudulently represented to the public, and various rulemaking and governing bodies, that the aluminum bats they produce perform like wood bats (Exhibit 13). They purposely have withheld critical testing information regarding bat performance from the NCAA because they do not want to reveal the truth about the performance of aluminum bats. And, without basis, they have attempted to divert attention by blaming the liveliness of the baseball, the designated hitter, small strike zones and poor pitching.

Documents turned over to the NCAA in July of 1998 by Petitioner repeatedly revealed a pattern of behavior by the aluminum bat manufacturers designed to cover-up the truth and mislead both the NCAA and the public. (Exhibit 13) One example of how the two major aluminum bat manufacturers have worked together to deceive the NCAA is found on a fax cover sheet that was accompanied by Richard Brandt's second draft of a supposedly "independent" field test report on bat performance. One aluminum bat company executive wrote to the other, "I think this is the time to hit the NCAA with the ball COR (coefficient of restitution) and small difference in 1.15 vs. 1.14 BPF." Also found on the fax cover sheet was the directive to "Blame the ball." Amazingly, executives from both companies were allowed to edit the report before it was sent to the NCAA.

At the end of the "independent" report, there is a note "Good job Richard!! (Dr. Richard Brandt) Thanks a bunch", Dewey. (Dewey Chavin, Easton Sports). This document was faxed from Easton directly to Louisville Slugger for changes before going to Dr. Brandt for publishing. (Exhibit 30)

The Rules Committee learned in July 1998 that most of the information it had

cloud the issue and hide the facts. The modus operandi of the aluminum bat manufacturers is to confuse and mislead. By confusing and misleading the Rules Committee, governing bodies, coaches, players, media and parents, it is their hope that the issue will never gain enough support for change. Delay! Delay! Delay!

Another reason this unreasonable risk of injury has been allowed to continue is due to the lawsuits and threats of lawsuits that have been engaged by the aluminum bat manufacturers. The governing bodies have been reluctant to set meaningful performance standards for fear of litigation from the manufacturers. This fear became a reality when Easton filed a $267 million antitrust lawsuit against the NCAA after it announced that its

Executive Committee had approved a nonwood bat-performance standard with a

.er hour.

Likewise, when Easton learned that most Division I, II and III conferences were wanting to use wood or wood composite bats beginning in January 1999, its legal counsel issued a threatening letter to Conference Commissioners. In the letter, Easton's counsel stated, "We understand that your conference is considering adopting the NCAA's new baseball bat requirements even before the August 1999 date set by the Executive Committee of the NCAA. We believe this would be a very serious mistake, which could force Easton to begin litigation against your conference to protect its interests." The letter concluded with the following statement: "Thus, there is no reason for a rush to judgment here. Safety is not being compromised. By the time the rule is to take effect, Easton's $250 million antitrust lawsuit against the NCAA will have been resolved or gone to trial. Any more rapid action will only spawn more expense, more mistakes and more litigation." (Exhibit 31)

A third reason this unreasonable risk of injury has been allowed to continue is due to the influence of money. In the early 1990s, Easton and Louisville Slugger began signing coaches from the top Division I baseball programs to personal-service contracts. In addition to free bats, bat bags, batting gloves, t-shirts, etc., the manufacturers paid the coach to exclusively endorse their products. Top coaches earned anywhere from $15,000-$30,000 in the early years and now earn as much as $80,000. These coaches are now on the payroll of the aluminum bat companies, and have a vested interest in seeing that the company's products are used at the college level. The bat companies have repeatedly called upon these coaches to lobby for no rule changes. (Exhibit 31B)

This fact was made painfully clear in a 1998 game between Texas Tech and Kansas in which a Kansas relief pitcher was hit by a line drive that shattered his kneecap. As the player was taken off the field, Texas Tech coach Larry Hays said to first base

be done with the bats to give pitchers a chance. When Yeast asked why nothing had been done to date, Hays commented, "Because all of us Division I coaches are making too much money from the bat manufacturers."

In the documents turned over to the NCAA by Petitioner, a former Louisville Slugger Consultant, it was revealed that Louisville Slugger and Easton had worked together to fix the prices of aluminum bats on the market, thereby commanding higher and higher prices. Dealers are required to sell bats at fixed prices or lose their dealership (Exhibit 32). The aluminum bat manufacturers are fearful of a batted-ball exit-velocity standard because it will force them to be competitive in a market with approximately 17 other manufacturers, thereby causing a substantial decrease in the extraordinary profit margins they are enjoying from aluminum bat sales.

The aluminum baseball bat manufacturers know that sales are driven by technological innovations. They feel the only way to profit in this very competitive industry is by developing a nonwood baseball bat that performs at a higher rate than the competition in terms of batted-ball exit velocity and overall performance. Above all, they fear a competitive market if wood-like bat performance standards are approved by governing bodies and all bats have to perform the same as wood bats.

Deceit, lawsuits, threats of lawsuits, and the influence of money have driven this issue for the past fifteen years. Despite the extensive independent testing that has been done by James Sherwood and Dr. Crisco, which has provided ample scientific bases for both the need and the ability to implement a wood-like performance standard, and despite the recommendation of the Research Panel, the Rules Committee, Dr. Sherwood, Bahm Research, and the Executive Committee to implement a wood-like standard, deceit, lawsuits and the influence of money have once again resulted in a compromise with the aluminum bat manufacturers. Unfortunately, it has done so at the expense of the health and safety of the athlete.

Summary of Engineering and Technical Studies

The following independent engineering and technical studies have been conducted to assess the performance of aluminum bats versus that of a traditional wood bat. As the studies reveal, the exit velocity and level of performance are significantly higher for aluminum bats than for traditional wood bats, which creates an unreasonable risk of injury for the athlete.

Program to Develop Baseball Bat Performance Procedures Using a Dynamic Hitting Machine and Provide Verification with Laboratory Test Methods, presented by Fallon/ Sherwood/Collier/Mustone to Major League Baseball. The researchers conducted an independent evaluation of the Baum Hitting Machine and found that the test configuration and test procedures ensure an accuracy of measured exit ball velocities within 1 mph on a precise hitting trajectory. They also concluded the difference in ball-

for the Raw Data Method, and 7-8 mph for the Relative Bat Performance and Projected Field Performance Methods. (Exhibit 33)

Wood Bat Ball-Exit Speed Database, presented by James Sherwood. The researcher calculated the average ball-exit speeds for 32-inch / 29-ounce, 33-inch / 30-ounce and 34-inch / 31-ounce wood bats using the Baum Hitting Machine. The 32/29 bats hit 93.712 mph, the 33/30 hit 92.328 mph and the 34/31 hit 90.538 mph. He recommended that any ball-exit-speed rule should be relative to known solid white ash wood batted-ball speeds. He also stated that if wood bats are considered the safe level for play, then it is difficult to defend, from a safety standpoint, any level of bat performance above that of comparable wood. (Exhibit 17)

Baseball Bat Performance: A Batting Cage Study, presented by Dr. Joseph J. "Trey" Crisco, III. Dr. Crisco recorded the exit velocity of batted balls using aluminum and wood bats in an indoor batting cage and surmised that in bats clearly outperform wood bats. His findings suggest that maximum batted-ball speed is generated from bat-swing speed and barrel efficiency, or trampoline effect. He also verified the claim that a pitcher needs .40 seconds to react and defend his position at 52-53 feet from the bat-ball impact point. (Exhibit 20)

NCAA Research Program on Bat and Ball Performance, presented by Dr. Joseph J. "Trey" Crisco, III. Dr. Crisco stated that the acceptable level of risk is the major issue in regulating bat performance, and that the specifics of a standard test methodology are secondary. He noted that extensive data from studies on impact injuries to a wide range of tissue (e.g., muscle, bone, brain), and on the reaction times of subjects, clearly indicate that increases in impact velocity would increase the severity and the frequency of injury. He found that bat speed was shown to have a stronger correlation with bat moment of inertia than bat weight, which suggests it would be more effective to regulate weight distribution (balance point) than overall bat weight. (Exhibit 10)

1999 Aluminum vs. Wood Bat Performance Study, presented by Coach Bill Thurston, Amherst College. Coach Thurston followed 96 Division I baseball players and tracked their statistics using the 1999 aluminum bat (2 5/8-inch diameter, minus-3 length-to-weight unit differential) in the spring college season, and a wood bat during competition in the Cape Cod Summer League. The 96 hitters averaged .334 with the metal bat and .248 with wood, a difference of .086. The difference in 1998 and 1997 was .082 and .107, respectively. While 79 percent of the hitters hit over .300 with metal, only 8 percent hit over .300 with wood. (Exhibit 34)

Wood vs. Aluminum Study, presented by the Central Illinois Collegiate League. The CICL, which is a collegiate summer league that uses wood bats, compared the statistics for the last three years it used metal bats (1987-89) with the most recent nine seasons using wood bats. The league has witnessed a 25 percent drop in scoring; a 60 percent drop in home runs per game; a 10 percent drop in batting average; and a game time that has decreased by 35 minutes. (Exhibit 35)

Division I and College World Series Statistical Trends, presented by the NCAA. The NCAA has tracked statistical trends at the Division I level since 1970. In 1973, the last year that wood bats were used in college baseball, team batting averages were .266. Teams scored 5.07 runs scored per game, hit .42 home runs per game and had earned-run averages of 3.46. In 1998, team batting averages were .306, a record high. Teams scored 7.14 runs per game, hit 1.07 home runs per game and had earned-run averages of 6.09, also record highs. (Exhibit 36)

SGMA-NCAA Field Test Preliminary Report, presented by Richard Brandt. Mr. Brandt reported on a 1995 field test that was conducted in California with 28 Division I baseball players. The main purpose of the test was to measure the performance of various bats. Mr. Brandt, who was hired by the SGMA to conduct the study, jeopardized the authenticity of the results by allowing Easton and Louisville Slugger representatives to edit the results of the test. (Exhibit 30)

James A. Sherwood, Director Baseball Research Center, University of Massachusetts, Brief Vitae, (Exhibit 40)

Year 2000 NCAA Baseball Bat Rule, Jim Sherwood, (Exhibit 37)

What's The Difference between Wood and Aluminum Baseball Bats, Jim Sherwood, 3-1-99, (Exhibit 38)?

Test Protocol for Wood Like Standards, Steve Baum, (Exhibit 39)

Position of a Pitcher from Plate, Bill Thurston, NCAA, (Exhibit 34-A)

Trampoline Effect Metal Bats, Steve Baum, (Exhibit 38-A)

BHM Hitting Machine Mechanics, Steve Baum, (Exhibit 38-B)

BHM Baum Hitting Machine Analysis for MLB, Lawrence Fallon, 10-1-97, (Exhibit 37-A)

1998 NCAA Division I Baseball Mid-Season Trends, NCAA Rules Committee, 4/98, (Exhibit 13-B)

Research Newsletter Testing Reveals Danger of Metal Bats, Steve Baum, (Exhibit 30-A)

Exit Velocity Study, Batted Ball, Steve Baum, (Exhibit 32-A)

Children's Soft Core Baseballs May Not Lower Risk of Fatal Injury, Institute for Preventative Sport Medicine, David H. Janda, 4-6-98, (Exhibit 32-B)

NCAA Softball Bat Testing, Fluid Technologies, Inc., 8-7-97, (Exhibit 33-B)

Donald Berder, Wood Materials and Engineering Laboratory, Washington State University, (Exhibit 33-A)

Wood Bat/Aluminum Bat Comparison Test, Balance Points, Sweet Spot, Worth, (Exhibit 35-A)

Cape Cod League Study 1983 and 1984, Aluminum to Wood, Bill Thurston, (Exhibit 35-B)

It's A Different Game, Bill Thurston, Studies and Comparisons of 1994-1997, (Exhibit 36-B)

A Game Out Of Balance, Bill Thurston, 1998 Hitting Statistics and Comparisons, (Exhibit 36-A)

Wood Bat Data, 7-10-97, Sports Engineering, Fallon, (Exhibit 37-B)

Comparison of Wooden and Graphite Baseball Bats, Dr. Richard Brandt, (Exhibit 39-A)

Frequency Response Functions, Model Analysis and Controls Laboratory, 9/97, (Exhibit 40-A)

A Rapid Compliance for Baseball Bats and Balls, National Institute for Sports Science and Safety, 11-27-97, (Exhibit 39-B)

Relationships Among Baseball Bat Weight, Moment of Inertia, and Velocity, America Sports Medicine, 8-20-97, (Exhibit 40-B)

Conclusion

Although there is a certain level of risk involved in playing the sport of baseball, the level of risk associated with wood bats has generally been accepted by all associated with the game as the "reasonable" level of risk. Therefore, any greater level of risk than that presented by traditional wood bats is unreasonable. After extensive testing and research, there is simply no question that the aluminum bats today substantially outperform traditional wood bats, and that the risk of serious injury to pitchers and infielders has become more prevalent. As evidenced by (Exhibit 1), both the frequency and the severity of injuries resulting from athletes being struck by baseballs hit by these high-performance aluminum bats indicates that the use of these bats present an unreasonable risk of injury.

Since its beginnings, the sport of baseball has attracted participants of all ages and levels of ability - from amateur to professional, and from organized leagues to neighborhood sandlot games. In 1998, participation statistics revealed that approximately 5 million participants were playing the sport of baseball in some organized form, and of these 5 98% were under the age of 18. (Exhibit 2) However, due to the extremely large number of organized baseball leagues throughout the country, many different governing bodies have been given the task of ensuring that the sport is both safe and enjoyable, and that the integrity of the game itself is maintained.

Unfortunately, aluminum bat manufacturers have taken advantage of the fragmented nature of the sport's organization and rulemaking authority, and have used deceit, threats of lawsuits, and the influence of money to prevent meaningful bat performance rules from being implemented. The course of events in the NCAA's recent attempt to enact a bat performance rule provides the perfect example of this conduct, and the powerful effect it has had on this governing body's inability to implement a bat performance rule that all persons involved believe is necessary to ensure the safety of the athletes.

Therefore, due to the tremendous number of participants that are at risk, the large number of rulemaking bodies, and the conduct of the aluminum bat manufacturers that has rendered these numerous rulemaking bodies ineffective in enacting a meaningful bat performance rule, it is reasonably necessary that the CPSC issue a rule to eliminate or reduce the risk of injury, and to recall all nonwood baseball bats that exceed the performance of wood baseball bats. The failure of the CPSC to issue the rule requested, and to institute the requested recall, will continue to expose consumers to the unreasonable risk of injury that is presented by the use of these high-performance aluminum bats.

Two of the primary purposes of the CPSC are to:

1.) protect the public against unreasonable risks of injury associated with consumer products, and

2.) develop uniform safety standards for consumer products and to minimize conflicting state and local regulations

Therefore, due to the presence of conflicting regulations regarding baseball bat performance, and the unreasonable risk of injury presented by high-performance aluminum bats, it is appropriate and necessary for the CPSC to issue the rule requested, and to institute the recall requested.

Accordingly, petitioner requests that, based upon the scientific studies and research that have already been performed regarding this issue, and the nature and severity of the risks involved, the CPSC issue a rule requiring the wood-like performance of all nonwood baseball bats, and recall all nonwood baseball bats that exceed the performance of wood baseball bats and impose fines on the bat manufacturers for failure to report safety issues to CPSC as required by Federal Law.

Request to Initiate Rulemaking and Other Actions

Based upon the unreasonable danger and risk of injury to consumers that high-performance nonwood bats present, Petitioner hereby requests the CPSC issue a rule requiring the wood-like performance of all nonwood baseball bats, and recall all nonwood baseball bats that exceed the performance of wood baseball bats and impose a penalty on the bat manufacturers for their failure to report information that non-wood bats create unreasonable risk of serious injury or death as prescribed by Federal Law.

A suggested test protocol is attached that was submitted to the NCAA and NFHS. This protocol would establish wood-like performance in non-wood bats. (Exhibit 39)

J. W. MacKay, Jr., Petitioner

Date: April 11, 2000

EXHIBIT INDEX

Exhibit 1	News accounts of reported injuries by batted balls, 1993-2000
Exhibit 1-A	News account of Bat Performance Issue, 1993-2000
Exhibit 1-B	Affidavit of J. W. MacKay, September 27, 1997
Exhibit 2	1998 Baseball Participation by Market Segment, 1998
Exhibit 2-A	Softball NCAA Women's Softball Rules Study Bats and Balls, 12-30-99
Exhibit 2-B	MacKay Patents Assigned to H & B Louisville Slugger, 1993-1999
Exhibit 3	1973 and 1994 NCAA Baseball Rules
Exhibit 3-A	Baseball Bat Models and Prices, 2000
Exhibit 3-B	Softball Bats Models and Prices, 2000
Exhibit 4	NCAA Baseball Committee Minutes, July 9-12, 1984
Exhibit 4-A	Worth letter Summary 10 Years Research 7-17-85, Louisville Slugger Report, Re: Wood Bats, 1985
Exhibit 4-B	Louisville Slugger letter to NCAA, Re: Bat Specs, 6-24-86, Louisville Slugger letter to Coach, Wood Bats Available, 7-6-86
Exhibit 5	NCAA Baseball Committee Minutes, November 5-8, 1984
Exhibit 5-A	Easton letter to NCAA, Thurston, Bat Recommendations, 11-10-86
Exhibit 5-B	Diamond Sports letter to NCAA, Monitoring Bats, 6-21-86
Exhibit 6	NCAA Baseball Committee Minutes, July 13 – 16, 1986
Exhibit 6-A	Mississippi State University Letter to Worth, 12-18-87
Exhibit 6-B	NCAA letter to bat manufacturers, Re: Bat Specifications Meeting 11-7-86
Exhibit 7	NCAA Baseball Committee Minutes, November 17-20, 1986 Recommendation Subcommittee Non-Wood, NCAA letter to Worth
Exhibit 7-A	Letter, Thurston to Subcommittee on Bats, 10-28-88
Exhibit 7-B	Jess Heald, Worth, Letter warning of dangers of Super Bat, 2-24-92

Exhibit 8	NCAA Memorandum, from Bill Thurston to selected college baseball coaches, Re: non-wood bat performance survey, 6-11-92
Exhibit 8-A	NCAA letter to bat manufacturers, 1988 Black magic Benchmark, 6-9-92
Exhibit 8-B	Softball Bat patent filed 6-92 and 6-93, Increased Performance
Exhibit 8-C	Easton letter to NCAA, Bat companies confirms bat companies not to improve performance, 4-19-92
Exhibit 8-D	Manning letter to Schupp, Business Interests, 6-15-92
Exhibit 8-E	NCAA Baseball Committee Minutes, 7-9-92
Exhibit 8-F	Manning letter to MacKay, 9-92
Exhibit 8-G	Manning letter to Archer, 10-21-92
Exhibit 8-H	Manning letter to MacKay, 11-92
Exhibit 8-I	Manning letter to Archer, 11-24-92
Exhibit 8-J	Insurance Certificates, 10-7-92 to 6-26-97
Exhibit 8-K	Easton letter NCAA, New Innovations, 3-19-93
Exhibit 8-L	Alcoa Protocol, C405, 11-23-93
Exhibit 8-M	Manning letter MacKay wants to de-tune, 9-93
Exhibit 8-N	Manning letter, De-tuned bats, MacKay, 9-93
Exhibit 8-O	Manning letter MacKay, Non-Conforming Product, 9-26-94
Exhibit 8-P	Manning letter Archer, Bat Testing, 8-16-94
Exhibit 8-Q	Manning letter Alcoa, 4-94
Exhibit 8-R	Manning letter Bradley, NFHS Rule Violation, 5-16-95
Exhibit 8-S	Manning letter MacKay, Easton Game Bats, 8-26-95
Exhibit 8-T	Manning letter Archer, Rules Committee Presentation, 6-29-95
Exhibit 8-U	SGMA letter to NCAA, 1994 Performance Standard, 7-13-95
Exhibit 8-V	Manning letter Archer, Consequences, 9-3-95
Exhibit 8-W	NCAA Baseball Rule Committee Minutes, 9-1-95
Exhibit 8-X	NFHS letter to SGMA, 9-26-95
Exhibit 8-Y	NCAA letter to Archer, 10-20-95
Exhibit 8-Z	Brandt letter to Archer, 10-2-95
Exhibit 9	Easton letter to ABCA Coaches, We need your help, 11-11-95

Exhibit 9-A	Easton letter to NCAA stating that Easton was building bats to 1994 performance levels, 11-10-95
Exhibit 9-B	NCAA letter stating 1994 Bat Performance Levels, 11-28-95
Exhibit 9-C	Worth letter to NFHS, 10-13-95
Exhibit 9-D	NFHS letter to Worth, 10-20-95
Exhibit 9-E	ASTM letter to Softball Association, 10-30-95
Exhibit 9-F	Fax-Easton, H & B, Worth, Brandt BPF, 10-16-95
Exhibit 9-G	Bat Issue Report, Thurston, 11-13-95
Exhibit 9-H	Thurston letter to MacKay, 11-20-95
Exhibit 9-I	Thurston letter to NCAA, 11-22-95
Exhibit 9-J	MacKay letter to Archer and Clark, Illegal bats, 11-22-95
Exhibit 9-K	MacKay letter to Hillerich, Serious player injury, 12-4-95
Exhibit 9-L	Thurston letter Brandt, Test bats, 12-4-95
Exhibit 9-M	Alcoa legal department letter, NCAA, 12-21-95
Exhibit 9-N	Easton letter to NCAA, 1994 performance level, 2-21-96
Exhibit 9-O	Mark Johnson letter to Hillerich, Bats, 5-29-96
Exhibit 9-P	Archer letter To Whom It May Concern, 5-21-96
Exhibit 9-Q	Press Release, ABCA, Wood Performance, 6-4-96
Exhibit 9-R	NCAA letter to Budget Subcommittee, 7-1-96
Exhibit 9-S	NCAA lawyer letter to Briendenthal, 7-1-96
Exhibit 9-T	Easton letter to Dempsey, NCAA, 9-26-96
Exhibit 9-U	Dempsey, NCAA letter to Easton, 10-22-96
Exhibit 9-V	Easton letter to Dempsey, NCAA, 1-15-97
Exhibit 9-W	SGMA letter to Rules Committee, NCAA, 3-17-97
Exhibit 9-X	Archer Telephone Conversation, 7-30-97, and MacKay Retirement Package, 7-14-97
Exhibit 9-Y	Easton letter to Rules Committee, NCAA, 7-22-97
Exhibit 9-Z	SGMA letter to Rules Committee, NCAA, 7-2-97
Exhibit 10	NCAA Research Program on Bat and Ball Performance dated October 1996 – September 1997 by Dr. Trey Crisco
Exhibit 10-A	Softball and Baseball Test Showing BPF test flawed-MacKay

Exhibit 10-B	Letter from Richard Brandt to NCAA Baseball Rules Committee, BPF for slow pitch softball, 11-17-97
Exhibit 10-C	MacKay resignation letter to Hillerich, 8-28-97
Exhibit 10-D	NCAA letter to Easton, 9-18-97
Exhibit 10-E	SGMA letter to bat companies, 12-19-97
Exhibit 11	Letter to High School Federation from SGMA dated June 8, 1998, Re: Brandt BPF tests
Exhibit 11-A	China Lake Naval Station Test, Louisville, 1-5-98
Exhibit 11-B	Sports Illustrated Article, Danger at the Plate, 1-12-98
Exhibit 11-C	NCAA letter to Easton, 2-3-98
Exhibit 11-D	Worth letter to SGMA, 2-17-98
Exhibit 11-E	Pitcher Hit By Batted Ball Survey, Thurston, 6-15-98
Exhibit 11-F	NCAA Memorandum to Colleges, 9-31-98
Exhibit 11-G	NCAA Memorandum to Colleges, 9-31-98
Exhibit 11-H	MacKay test systems to NCAA, 9-16-98
Exhibit 11-J	Easton lawyer letter to West Coast Conference, 11-17-98
Exhibit 11-K	NCAA Memorandum to Colleges, 12-4-98
Exhibit 11-L	NCAA memo to Sherwood, test protocol, 12-10-98
Exhibit 11-M	NCAA Memo to colleges, 1-14-98
Exhibit 11-N	Easton Memo to Easton dealers, 10-5-99
Exhibit 11-O	Thurston letter to MacKay, 10-27-99
Exhibit 11-P	Thurston report to Rules Committee, 11-8-99
Exhibit 11-Q	Comparisons Aluminum Bat Performance, 98-99, 11-99
Exhibit 11-R	NCAA memo to NCAA Institutions, 1-1-99
Exhibit 11-S	NCAA memo to Bat Manufacturers, 11-24-99
Exhibit 11-T	Louisville and ABCA Hall of Fame, 7-99
Exhibit 11-U	E-Mails-NCAA, Worth, Sherwood, 2-7-99
Exhibit 11-V	Sherwood fax to MacKay, 2-14-99
Exhibit 11-W	Checks and Balances of Systems Protocol, 3-8-00
Exhibit 11-X	Sherwood Web Site Page, 2-21-00, Fox Sports Web page, Sports Illustrated Article, 3-22-00

Exhibit 11-Y	ESPN Bat Article, 3-31-00
Exhibit 11-Z	NCAA new article on bat loophole in testing, 4-10-00
Exhibit 12	Letter from ABCA to NCAA dated July 9, 1998 re: recommendation of wood bat standard
Exhibit 13	MacKay documents handed over to the NCAA at Summit Meeting in July 1998
Exhibit 13-A	Transcript of bat Summit Meeting, Ritz Carlton, Kansas City, July 14, 1998
Exhibit 13-B	1998 NCAA Division I Baseball Mid Season Trends, NCAA Rules Committee, 4/98
Exhibit 14	Letter from Cedric Dempsey (NCAA) to NCAA member institutions dated August 28, 1998, re: baseball bat safety
Exhibit 14-A	News Release on Performance Restrictions, NCAA
Exhibit 14-B	News Release on Performance Restrictions, NFHS
Exhibit 15	Packet from Easton to NCAA coaches dated November 12, 1998
Exhibit 15-A	Keep the Game the Same-Joe Hicks, Diamond Sports
Exhibit 15-B	Heiden letter to Easton lawyers, re: CPSC Regulatory Attention
Exhibit 16	Memorandum from NCAA Baseball Rules Committee to NCAA member institutions dated December 4, 1998, re: Easton Sports' recent letters
Exhibit 17	Letter from James Sherwood to NCAA dated January 8, 1999, re: wood bat ball exit speed database
Exhibit 18	NCAA press release dated January 15, 1999, re: creation of panel to study baseball bat issues
Exhibit 18-A	Baum Lawsuit against NCAA and Bat Manufacturers
Exhibit 19	NCAA new release dated June 21, 1999, re: Research Panel recommends wood-like performance standard
Exhibit 19-A	Sanchez Lawsuit against Louisville Slugger
Exhibit 20	Baseball Bat Performance: A Batting Cage Study, dated July 14, 1999 by Dr. Trey Crisco
Exhibit 20-A	Brett Lawsuit against Louisville Slugger

Exhibit 21	News Release by the High School Federation dated July 1999, re: recommendation for a bat rule change, wood performance standard
Exhibit 21-A	Wall Street Journal Article on Balance Point of Bats, 1985
Exhibit 22	Letter from James Sherwood to NCAA dated February 25, 2000, re: changes to NCAA bat testing protocol
Exhibit 22-A	Dr. Crisco Study, 7-14-99, Five Points of Safety
Exhibit 23	NCAA Press Release dated September 28, 1999, re: NCAA Executive Committee approves bat standards
Exhibit 23-A	Archer Deposition-Discuss Safety with MacKay, 4-98
Exhibit 23-B	Easton letter to dealers, Lawsuit Settlement with NCAA, 10-5-99
Exhibit 24	Email from NCAA to James Sherwood dated February 7, 2000, re: Requesting discussion of changes in bat protocol be kept internal
Exhibit 24-A	Archer Deposition, National Debate on Safety, 4-98
Exhibit 25	High School Federation Press Release dated December 10, 1999, re: proposed bat performance standard revision
Exhibit 25-A	Archer Deposition-Saw Brandt Reaction Study, "Deadly as Hell", 4-98
Exhibit 26	High School Federation Press Release dated January 7, 2000, re: NFHS Board of Directors approves new bat rule
Exhibit 26-A	Archer Deposition-Safety is Confidential and Proprietary, 4-98
Exhibit 27	Videotapes of Fox Sports and ESPN investigative reports re: bat performance issue, (seven tapes)
Exhibit 27-A	Archer Deposition-Illegal Diameter Bats Shipped, 4-98
Exhibit 28	NCAA Injury Surveillance System data
Exhibit 28-A	Archer Deposition-C405 Serious Player Injury, 4-98
Exhibit 29	Letter from Bud Cosgrove (ASTM) to all concerned softball associations dated October 30, 1995, re: reaction time problem and safety issue regarding high-performance aluminum bats
Exhibit 29-A	Archer Deposition-Injunction Denied For MacKay to Discuss Safety, 4-98

Exhibit 30	Fax from Dewey Chauvin (Easton) to George Manning (Louisville Slugger) dated November 1999, re: Brandt's report to the NCAA
Exhibit 30-A	Research Newsletter Metal Bats Dangerous-Baum
Exhibit 30-B	BHM Test Results, Wood vs. Metal
Exhibit 31	Letter from counsel for Easton to West Coast Conference Commissioner dated November 17, 1998, re: threat of lawsuit
Exhibit 31-A	Letter from legal department, Alcoa Aluminum to John Black, counsel for NCAA, 11-17-98
Exhibit 31-B	Easton letter to ABCA coaches requesting help
Exhibit 32	Letters from Louisville Slugger and Easton to retail stores dated April 14, 1998, re: pricing policy
Exhibit 32-A	Exit Velocity Batted Ball-Baum
Exhibit 32-B	Children's soft core baseballs may not lower risk of fatal injury, Institute Sports Medicine, 1998
Exhibit 33	Final report on Program to Develop Baseball Bat Performance Procedures, by Lawrence P. Fallon dated December 11, 1997
Exhibit 33-A	Evaluation of Laminated and Solid Wood Bats, Washington State University, Donald A. Bender, 4-24-98
Exhibit 33-B	NCAA Softball Bat Testing, Fluid Technologies, Inc., 8-7-97
Exhibit 34	Study comparing aluminum and wood bat performance for 1999, by Bill Thurston
Exhibit 34-A	Position of Pitcher from Plate, Thurston, NCAA
Exhibit 34-B	Static and Dynamic Behaviors of Baseballs, Trey Crisco
Exhibit 35	Study by the CICL wood bat league re: aluminum and wood bat performance
Exhibit 35-A	Wood Aluminum Bat Comparison Tests, Worth
Exhibit 35-B	Cape Cod League Study-Aluminum to Wood, Thurston
Exhibit 36	NCAA Division I and College World Series Statistical Trends from 1970 to 1998
Exhibit 36-A	A Game Out Of Balance, Thurston, 7-7-98
Exhibit 36-B	It's A Different Game, Thurston, 7-7-98

Exhibit 37	Year 2000 NCAA Baseball Bat Rule, Jim Sherwood
Exhibit 37-A	BHM Baum Hitting Machine Analysis for MCB-Fallon
Exhibit 37-B	Wood Bat Data-Sports Engineering, Fallon
Exhibit 38	What's the difference between wood and aluminum baseball bats? Jim Sherwood
Exhibit 38-A	Trampoline Effect Metal Bats, Baum Research
Exhibit 38-B	BHM Hitting Machine Mechanics, Baum Research
Exhibit 39	Test protocol submitted to NCAA and NFHS to insure non-wood bats perform like wood-bats, 12-29-99
Exhibit 39-A	Comparison of Wooden and Graphite Baseball Bats, Dr. Richard Brandt
Exhibit 39-B	A Rapid Compliance for Baseball Bats and Balls, National Institute for Sports Science and Safety, 11-27-97
Exhibit 40	James Sherwood, Brief Vitae
Exhibit 40-A	Frequency Response Functions, Model Analysis and Controls Laboratory Bat, 9/97
Exhibit 40-B	Relationships Among Baseball Bat Weight, Moment of Inertia, and Velocity, American Sports Medicine, 8-97

Tab B

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: August 16, 2001

TO : Erlinda M. Edwards
Project Manager, Non-Wood Baseball Bats Petition CP 00-1
Division of Electrical Engineering, Directorate for Engineering Sciences

THROUGH: Warren J. Prunella, AED, Economic Analysis WJP

FROM : Terrance R. Karels, EC TRK

SUBJECT : Non-Wood Baseball Bats

This memo provides some market information for the Commission's consideration of Petition CP-00-1, Performance Requirements For Non-Wood (NW) Bats. The petition, filed by Jack W. MacKay, Jr., seeks the development of requirements that would set upper bound limits on the projectile speeds that batted balls can attain after contact with NW bats, speeds roughly equivalent to those attained after contact with a wooden bat. The petitioner alleges that pitchers are most at risk from batted balls after contact with NW bats.

The game of baseball has been played in the US for over 100 years. The participants range from about 4 years ("Tee-Ball") to over 70 years ("Seniors Leagues") of age. According to the **Sports Participation Survey**, sponsored by the Sporting Goods Manufacturers Association (SGMA), the industry trade group, there were some 5 million people playing baseball in some organized form in the US in 1998. According to the SGMA survey, an estimated 19 million people play baseball in some form each year (whether or not organized in a league structure). In a submission in comment to the petition, an official for the Little League reported that 98% of all baseball players in the US are under the age of 18.

According to a spokesman for baseball's Little League, there are 200,000 teams playing under that organization's structure. The average season is composed of 18 games. Little League seasons would then total about 3.6 million games. Thus, with a minimum of 2 pitchers per game (one for each team), the number of pitched games in Little League alone would total 7.2 million per year.

NW bats, which are constructed of aluminum and other metal alloys, were introduced in the late 1960s as a substitute for wooden bats. In 1972, high school and college governing bodies allowed the use of NW bats for the first time. In that year, NW bats accounted for 10% or less of bat sales; by 1999, however, NW bats accounted for 90% of bat purchases. The newer product was initially seen as a cost saving measure, due to the greater durability of NW bats.

While NW bats are somewhat more expensive than wooden bats (the average purchase price of wood bats is about $20 each, compared to about $38 each for NW bats), certain types of

NW bats can cost many times the cost of wooden substitutes. Industry sources reported that NW bats are also routinely replaced frequently, but the rate of replacement probably does not equal that for broken wood bats.

NW bats are now purchased primarily because of enhanced batter performance with the NW products. Manufacturers of wood and NW bats reported that NW bats have certain advantages over wood bats. NW bats can be made lighter than equivalent length wood bats, increasing the speed at which the NW bats can be swung. NW bats also have a larger "sweet spot" than wooden bats. (The sweet spot is the part of the bat that yields greater contact and generated power to the batted ball.) Further, laboratory studies have shown that balls hit with a NW bat can exceed the projectile velocity of those hit from wood bats. This finding is supported by studies conducted for the National Collegiate Athletic Association (NCAA), that showed increased batting averages and home runs per game as NW bats gained acceptance. Between 1995 and 1998, for example, batting averages increased 17 percentage points (even 20 years after the introduction of NW bats). Additionally, the average number of home runs per game increased from 0.7 per game to 1.07 per game, an increase of over 50%.

According to industry sources, nine US manufacturers account for virtually all domestic sales of NW bats. (Imports of NW bats are described as negligible.) These manufacturers are:

--- BombBat, Faith, NC
--- Easton Sports, Van Nuys, CA
--- Grover Products, Los Angeles, CA
--- Hillerich & Bradsby (Louisville Slugger), Louisville, KY
--- Nike, Beaverton, Pa
--- Power Flite (American Modern Metals), Kearny, NJ
--- Rawlings, Fenton, MO
--- Wilson (Demarini), Chicago, IL
--- Worth, Tullahoma, TN

While Hillerich & Bradsby, Nike, Rawlings, and Wilson are diversified, producing a wide range of sports-related equipment, the remaining firms concentrate on the production of bats. Two firms (Hillerich & Bradsby and Rawlings) account for some 80% or more of wooden bat production. Reportedly, there is a large number of smaller wooden bat manufacturers, some of which may be termed "garage-type" operations producing only limited numbers of bats per year.

Industry sources report the annual wholesale value of bats (both wood and NW) at $150 million per year. Because of differing purchasing practices --- some teams purchase directly from manufacturers at near-wholesale prices, while others purchase these products at retail outlets --- it is difficult to estimate an average retail price for bats. Based on the earlier-cited average "purchase price" of bats, and share of market controlled by NW bats, the average price of bats would be about "$35." Thus, there are perhaps 4.3 million bats sold per year.

Based on the share of market controlled by NW bats (90%), some 4 million NW bats would have been sold in 1999. Because of the inherent durability of NW bats, they are not as likely to be replaced due to catastrophic failure as wood bats. However, manufacturers have reported that such NW bats are often replaced after a year's service by major college programs. If a typical NW bat experienced a 2-3 year service life, we would expect that the number of NW

Tab C

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

DATE: January 30, 2001

TO: Erlinda Edwards, ES
Project Manager

THROUGH: Susan W. Ahmed, Ph.D., Associate Executive Director for Epidemiology
Russell H. Roegner, Ph.D., Director, Division of Hazard Analysis RR

FROM: Susan B. Kyle, Ph.D.

SUBJECT: Injury and Death Data Related to the Bat Petition, CP 00-1

SUMMARY

This memorandum summarizes available data on deaths and injuries associated with batted baseballs for use in the Commission's consideration of a petition from Mr. J. W. MacKay requesting that the Commission require that non-wood baseball bats perform like wood bats in order to reduce the risk of death and injury to players, particularly pitchers. Data from several sources were reviewed. These sources included U.S. Consumer Product Safety Commission (CPSC) files, information and published reports from the National Collegiate Athletic Association, information from Little League Baseball, Inc., and data submitted by the petitioner.

As reported by the petitioner, injuries and deaths have occurred to pitchers who were struck by balls batted with non-wood bats. CPSC staff is aware of 51 deaths due to ball impact from 1991 to the present, including 4 of the 5 deaths reported by the petitioner to have occurred in the U.S Of these 51 deaths, 17 were identified as being due to batted balls, 8 were identified as involving non-wood bats. These data showed no clear trend.

Based on currently available injury data, CPSC staff can neither confirm nor deny the petitioner's assertion that injuries to pitchers are increasing as bat performance characteristics change. Available information indicates that overall the numbers of injuries are declining and that the overall rate of injury is steady or declining. However, these data do not preclude the possibility that pitchers may be experiencing more injuries or more severe injuries from batted balls.

INTRODUCTION

On May 23, 2000, a submission from Mr. J. W. MacKay of Mount Pleasant, Texas was docketed as a petition requesting that the U.S. Consumer Product Safety Commission (CPSC) require that non-wood baseball bats perform like wood bats. The petition asserted that high-performance non-wood baseball bats represent an unreasonable risk of injury: "After extensive testing and research, there is simply no question that the aluminum bats today substantially outperform traditional wood bats, and that the risk of serious injury to pitchers and infielders has become more prevalent."[1] The petitioner included 10 three-ring binder notebooks[2] of information in support of the position that the frequency and severity of injuries to players resulting from being struck by balls batted with high-performance non-wood bats indicates that the use of high-performance non-wood bats represents an unreasonable risk of injury.

In order to issue a mandatory standard for non-wood bats, CPSC would have to "be able to conclude that the standard would reduce the risk of being hit by a batted ball by some specific amount."[3] There are several ways that this could be accomplished. One would be to demonstrate an increased risk of injury or death from balls batted with non-wood bats compared to balls batted with wood bats. This increased risk could result from either an increased number of injuries or deaths, or increased severity of injury. Any proposed standard would then have to establish that deaths and/or injuries would be lessened by some projected number or that injuries might be reduced in severity by some projected extent as a result of the proposed changes in non-wood bat performance. This memorandum provides information on deaths and injuries to assist in assessing this type of risk.

Another way to demonstrate the effects of a standard on risk would be to establish that current non-wood bat performance allows a quantified number of hits to exceed some threshold exit speed off the bat and that exceeding this threshold exit speed endangers the pitcher by providing insufficient time for him to react to the batted ball. Any proposed standard would then have to relate any proposed performance requirements to a reduction (or elimination) in the number of hits exceeding the threshold value and further determine what this would mean in terms of risk of injury to the pitcher. The information in this memorandum does not address this type of risk.

This memorandum reviews data currently available from several different sources, including CPSC, Little League Baseball, Inc., the National Collegiate Athletic Association (NCAA), and the petition itself to determine whether injuries involving balls batted with non-wood bats have been increasing either in frequency or severity.

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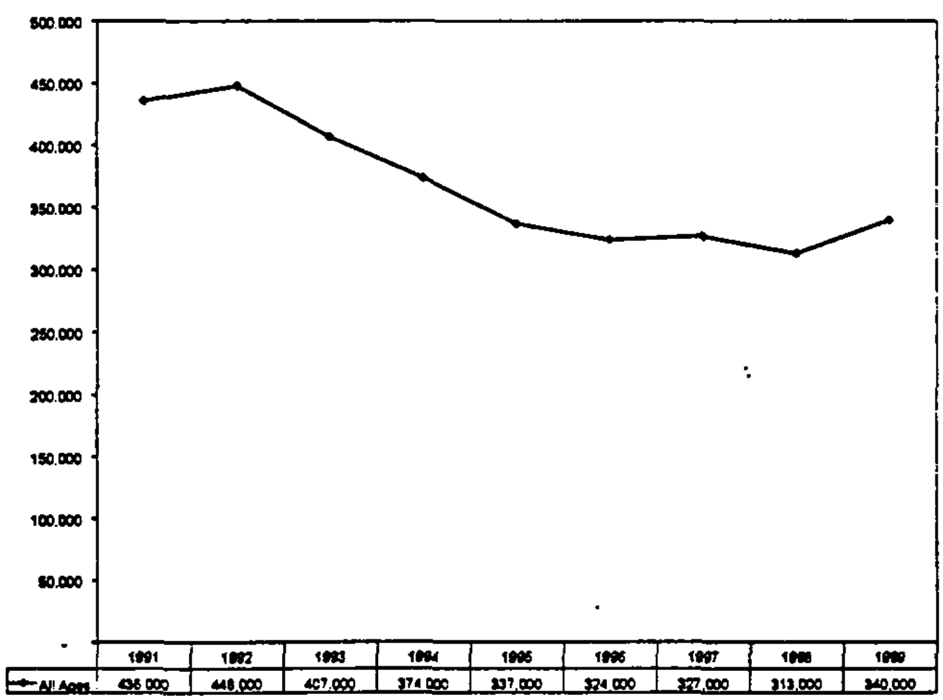
[1] Page 2, Petition CP00-01 from Petitioner J.S. MacKay, Jr., et al., U.S. Consumer Product Safety Commission, Washington, D.C., docketed May 23, 2000.
[2] Notebooks numbered 1-5 and 1B, 1C, 1D, 1E and 1F.
[3] *Letter from Stephen Lemberg, Assistant General Counsel, U.S. Consumer Product Safety Commission, to* J.W. MacKay, Jr., May 23, 2000.

DATA

NEISS Data. The National Electronic Injury Surveillance System (NEISS) is a probability sample of hospital emergency departments (EDs) in the U.S. There are currently 100 hospitals in the sample. ED medical records in each hospital in the sample are reviewed and descriptive data about the patient and the injury (age, sex, body part injured, diagnosis, whether treated and released, transferred, or hospitalized) are extracted and entered into the NEISS database. From the reported NEISS cases, national estimates of ED-treated consumer product-related injuries, including baseball-related injuries can be derived. Figure 1 presents the NEISS estimates of the number of baseball and softball-associated injuries for the time period 1991-1999.

Figure 1.
Estimated Number of Baseball- and Softball-Associated
Emergency Department-Treated Injuries
1991-1999
All Ages



Source: National Electronic Injury Surveillance System

There was a statistically significant (p=0.0111[4]) downward trend in the number of injuries during this time period, with an average decrease of 12,000 injuries each year.

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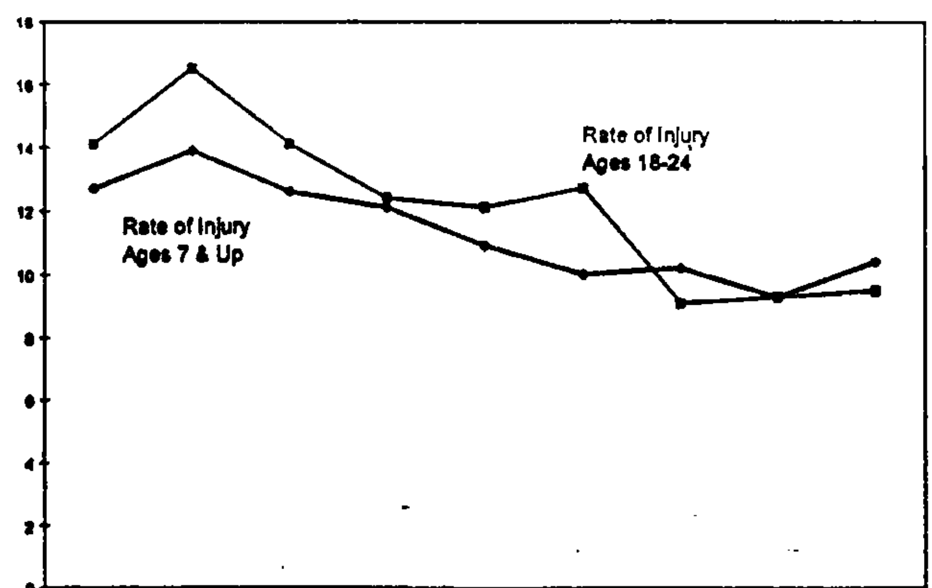
[4] The p-value is a measure of the probability that the observed trend might have happened by chance. Values range from 0 to 1.0. The smaller the p-value, the less likely that the result is due to chance. P-values of less than 0.05 are generally considered to be statistically significant.

To determine whether changes in participation might be responsible for changes in the number of injuries, participation data for people age 7 and older were obtained from the National Sporting Goods Association (NSGA). These data were obtained annually from a mail panel survey of more than 300,000 pre-recruited households. During the first week of January of each year, a self-administered questionnaire was mailed to 15,000 of these households asking about sports participation during the prior year by the male and female heads of household and up to two other household members who were at least 7 years of age. The sample of 15,000 was balanced to over-sample segments with lower return rates, so that the resulting return sample was correctly representative of the U.S. National estimates of the number of participants for any given sport were computed using weighting factors based on household size, gender of household head for single head households, household head age, household income, and region of the country.

Participation was defined as having engaged in the given sport more than once in the previous year. Overall rates of injury were calculated by dividing the total number of NEISS injuries by the total number of participants for each year. Rates of injury for different age groups were calculated by dividing the number of NEISS injuries for the age group by the number of age group participants. Results are presented in Figure 2 below.

Figure 2.
Rates of Baseball and Softball-Associated Emergency Department-Treated Injuries Per [redacted] Thousand Participants 1991-1999 Ages 7 and Up, and Ages 18-24



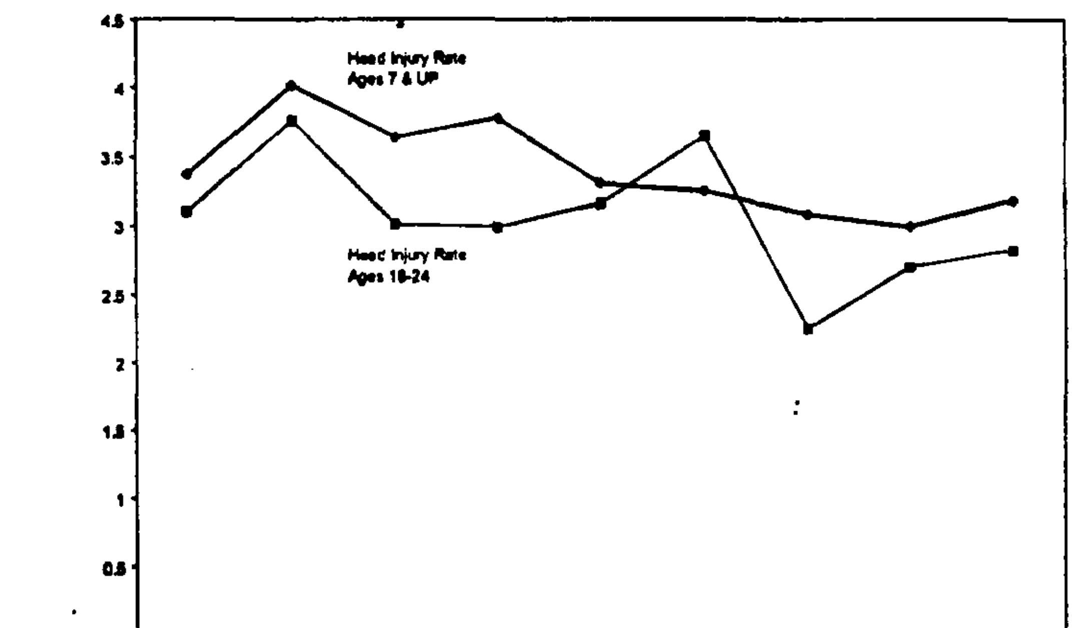
	1991	1992	1993	1994	1995	1996	1997	1998	1999
Rate18-24	14.1	16.5	14.1	12.4	12.1	12.7	9.1	9.3	9.5
Rate 7&UP	12.7	13.9	12.6	12.1	10.9	10	10.2	9.3	10.4

Sources: Injury Data: National Electronic Injury Surveillance System
Participation Data: National Sporting Goods Association

The rate of injury for ages 7 and up show a significant (p=0.0014) downward trend for the time period studied, with an average decrease of 0.5 injuries per year per [redacted] thousand participants. The rate of injury for 18-24 year olds also showed a significant (p=0.0010) downward trend in this time period, with an average decrease of 0.8 injuries per year.

Since a number of the injury incidents reported by the petitioner involved head or facial injury, trends in injury to the head region of the body were investigated separately. The head region included the NEISS body parts head, face, mouth, ear, eyeball, and neck. Rates of injury were calculated using the NSGA data as described above.

Figure 3.
Rates of Baseball- and Softball-Associated
Emergency Department-Treated Injury
Per [redacted] Thousand Participants
Head Region
1991-1999
Ages 7 & Up, and Ages 18-24



	1991	1992	1993	1994	1995	1996	1997	1998	1999
All Ages	3.37	4.02	3.64	3.78	3.31	3.26	3.08	2.99	3.18
Ages 18-24	3.1	3.76	3.01	2.99	3.16	3.65	2.26	2.7	2.82

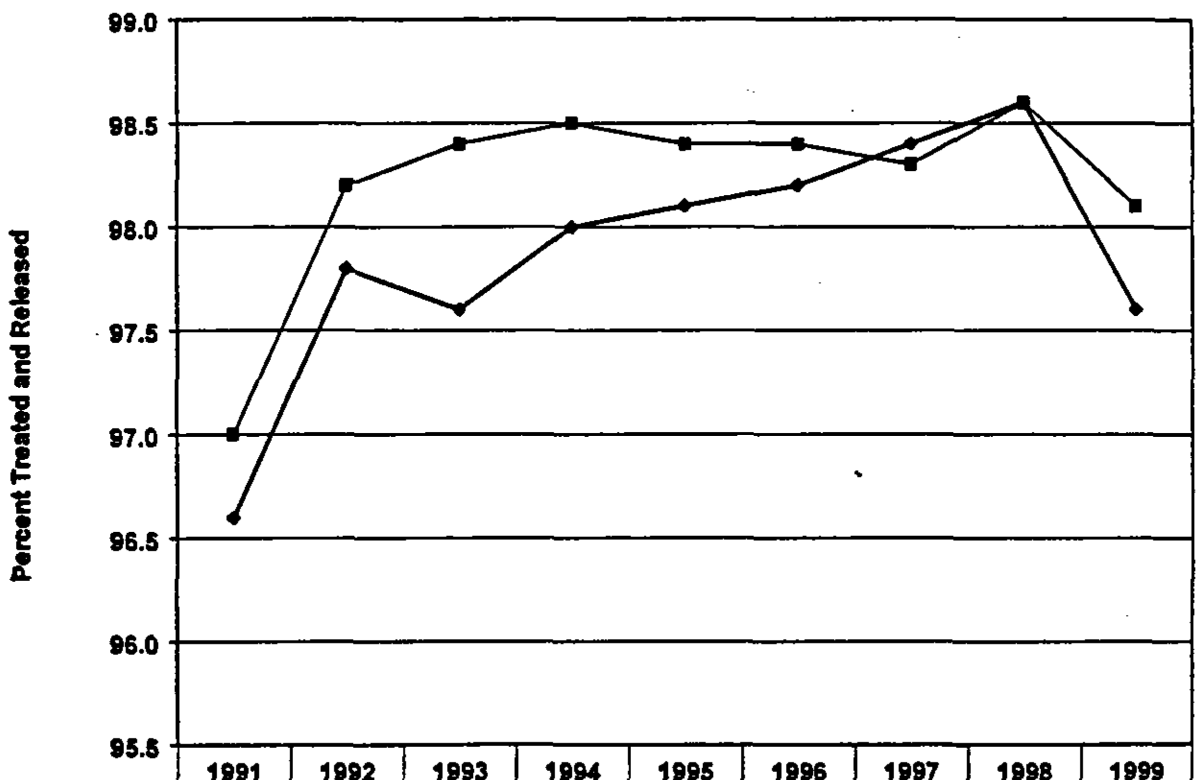
Sources: Injury Data: National Electronic Injury Surveillance System
Participation Data: National Sporting Goods Association

The rate of injury to the head region for all ages (ages 7 and up) decreased significantly over the time period (p=0.0303), with an average decrease of 0.09 injuries per [redacted] thousand participants per year. There was no significant trend in the rate of head injury in the 18-24 year old group (p=0.1482).

Severity of Injury. The percent of injuries that were treated and released was investigated to determine whether it had changed significantly over the 9-year time period. A decrease in the percent of injuries treated and released would indicate that the severity of injuries was going up, while an increase in the percent that were treated and released would mean that the injuries were less severe.

The following figure presents trends in the percent of baseball-associated injuries that were treated and released. Data are shown for all injuries for ages 7 and up, and for injuries to the head region (head, face, mouth, ear, eyeball, and neck) for ages 7 and up.

Figure 4.
Percent of Injuries which were
Treated and Released
All Injuries and Head Region Injuries
Ages 7 & Up
1991-1999



	1991	1992	1993	1994	1995	1996	1997	1998	1999
All Injuries	97.0	98.2	98.4	98.5	98.4	98.4	98.3	98.6	98.1
Head Region Injuries	96.6	97.8	97.6	98.0	98.1	98.2	98.4	98.6	97.6

Year

Sources. Injury Data: National Electronic Injury Surveillance System
Participation Data: National Sporting Goods Association

Neither trend was statistically significant (p=0.6655 for all injuries, and p=0.1448 for head region injuries).

Summary of NEISS Data. Overall, the number of injuries associated with baseball and softball during the nine-year period 1991-1999 showed a significant decrease. The participant-based rate of injuries also decreased significantly during this time period, as did head injury rates. There was no significant trend in the percent of injuries that were treated and released for all injuries or for injuries to the head region. However, the NEISS system does not provide information about player position or sufficient information to be able to determine how many injuries may have involved a batted ball. Therefore, these findings cannot preclude the possibility that injuries to pitchers from batted balls are increasing either in number or severity.

<u>CPSC Special Study</u>. Generally, to determine incident characteristics, such as whether an injury involved a batted ball, CPSC staff conducts special studies wherein the injured person is contacted and interviewed about the circumstances of the injury. CPSC staff has conducted only one such recent study of baseball- and softball-related injuries. This was a study of youth baseball protective equipment[5]. A major purpose of the study was to "develop information for the general public about what types of available protective equipment could prevent or reduce the severity of baseball-, softball-, and tee-ball-related injuries and deaths to children ages 5 to 14"[6]. Equipment reviewed included softer-than-standard balls, face guards for batting helmets, modified "safety bases", and chest protectors for batters. Because bats generally are not considered to be safety equipment and no bats are marketed as reducing the risk of injury (as some balls are), they were not reviewed in this study.

However, this study did report that of the 162,100 injuries to children related to baseball, softball and tee-ball in 1995, 31,900 (19.7%) occurred from being hit by a batted ball. What percent of these occurred to pitchers was not reported. This percentage is much higher than the 7 to 9% reported by the NCAA (see below) for batted ball injuries as a percent of total injuries. However, the CPSC studied a different age group, included injuries in all settings, not just organized games and practices, and included a wider range of skill level than is found in collegiate baseball. Since this was the only year in which a special study was conducted, no information is available through CPSC on any increase or decrease in batted ball injuries or their severity.

<u>Heiden Associates Analysis of NEISS Data</u>. Mentioned in the petition was a study by Heiden Associates commissioned by Honigman, Miller, Schwartz, and Cohn, Attorneys for Easton Sports, Inc. (See Easton Sports, Inc.'s Written Comments Concerning Petition Requesting Performance Requirements for Non-Wood Baseball Bats (CP 00-1), hereinafter referred to as Easton's Comments, Tabs 1 and 2.) In it Dr. Edward J. Heiden, former chief planning economist at CPSC, provides data from the NEISS system on injuries involving being hit by a batted ball. Dr. Heiden provided yearly estimates of total injuries and injuries involving being hit by a batted ball (Easton's Comments, Tab 2). The data indicated that 2.5 percent of all injuries associated with baseball involved being hit by a batted ball.

[5] Youth Baseball Protective Equipment Project Final Report, May 1996, Susan B. Kyle, Ph.D., Project Manager, U.S. Consumer Product Safety Commission.
[6] Ibid. page ii.

It is misleading to present this data as indicating conclusively the number of injuries involving batted balls and whether or not the number changed over time. Generally, for baseball and softball, the number of NEISS cases that have such highly specific information is not a high enough percent of the total number of cases to allow one to infer confidently about the total number of injuries.

For example, in the 1995 NEISS injuries which were used in the CPSC special study cited above, where the NEISS comments indicated that the player had been hit by the ball, 78% of the injuries gave no information as to whether the ball was thrown or batted but included only information such as "hit with baseball", "hit in nose with baseball", etc. These ball impact injuries with no information on whether the ball was batted or thrown represented about 35% of the total NEISS injuries in the study. An additional 14% of the NEISS injuries gave no scenario information at all, including only a comment such as "injured thumb playing baseball". Therefore about half the NEISS injuries (35% + 14%) gave no information about whether a thrown or batted ball may have been involved in the injury. The CPSC special study was conducted to fill in this missing information as well as obtain more details.

As noted above, CPSC staff has conducted only one special study of baseball-related injuries in recent years, so there is no information on trends in batted ball injuries available through CPSC.

Little League Data. Data from Little League Baseball, Inc., have also been cited regarding the number of injuries to pitchers from batted balls and trends in these numbers. Little League issued a statement that "there has been a 76 percent decrease in reported injuries to pitchers as a result of batted balls over the eight-season period beginning in 1992" (Easton's Comments, Tab 3).

Little League does not actually collect injury data. The data reported are claims filed with Little League's insurance carrier, CNA, for reimbursement of medical expenses. Such claims generally would be filed by people without primary medical insurance or whose medical accident insurance covered only part of the medical expenses. Such insurance coverage is referred to as "excess" insurance coverage. In either case, the player's parents or guardians would have to have been aware that such secondary coverage was available through Little League.

Excess insurance claims data are not generally recognized as a statistically valid method of estimating total numbers of injuries. This is due to issues concerning coverage and the filing of claims. Little League reports that 95% of the chartered Little League programs in the U.S. are enrolled in their accident insurance program (Easton's Comments, Tab 3). So Little League players generally have this secondary coverage. However, Little League presents no information establishing that their claims represent a significant portion of all medical claims filed and, more importantly, of all injuries that occurred. Absent such information, excess insurance claims cannot be considered to be statistically representative of all injuries.

A more accurate statement of the Little League data would be that excess medical insurance claims involving pitchers hit by batted balls have decreased in Little League. The causes for this may include a decrease in the number of pitchers injured or in the severity of batted ball injuries to pitchers, but these are not necessarily the only possible causes of such a decrease, and, in fact, neither is required for such a decrease to occur. The decrease in claims might be due to other factors such as changes in the number of players whose primary medical insurance covered the entire cost of the injury, for example. Without further information, it is impossible to determine what the cause of the decrease is. Little League has assumed that it was a decrease in the number of injuries, but has not established this as fact.

NCAA Data. The National Collegiate Athletic Association data are of particular interest because collegiate pitchers are considered to be at high risk of injury for two reasons: college age batters are likely to be the strongest and most skilled players using non-wood bats[7], and, therefore, most likely to have the fastest ball speed off the bat; and, among this high-power group of players, pitchers are closest to the batter.

Two different sources of NCAA data about injuries were provided in the petition submission: NCAA's Injury Surveillance System (ISS), and a Division I Baseball Injury Survey Pitcher Hit by a Batted Ball (Batted Ball Survey).

ISS. Participation in the NCAA's Injury Surveillance System by member schools is voluntary. ISS participants are "selected from the population of schools sponsoring a given sport. Selections are random within the constraints of having a minimum 10 percent representation of each NCAA division (I, II, and III) and region (East, South, Midwest, West). This sampling scheme assures a true cross-section of NCAA institutions which can be used to express injury rates representative of the total population of NCAA institutions sponsoring a particular sport....this system does not identify EVERY injury that occurs at NCAA institutions in a particular sport. Rather, it collects a sampling that is representative of a cross-section of NCAA institutions." (Easton's comments, Tab 6)

The definition of injury used by ISS is "one that:

1. occurs as a result of participation in an organized intercollegiate practice or game,
2. requires medical attention by a team athletics trainer or physician, and
3. results in restriction of the student-athlete's participation for one or more days beyond the day of injury." (Easton's comments, Tab 6)

The ISS data that were presented as pertinent to the petition are somewhat confusing. One document, "NCAA Injury Surveillance System (ISS) Baseball Injury Analysis" (Easton's Comments, Tab 7), is widely cited in the information submitted by the petitioner as establishing that only 3 percent of all NCAA baseball injuries are pitchers hit by batted balls, and that this percent has remained constant for several years. The document provides the following table.

[7] Professional players use wooden bats.

Table 1.
Percent of Injuries due to Pitcher Impacted with a Batted Ball
NCAA ISS Baseball Injury Analysis

Year	% Injuries due to Pitcher Impacted with a Batted Ball
1993	3%
1994	4%
1995	2%
1996	3%
1997	3%
1998	3%

Additional information in that document indicates that there were a reported 45 injuries to pitchers due to impact with a batted ball over the 6-year period 1993-1998. This is an average of 7.5 such injuries per year. If these 7.5 injuries were 3% of total injuries, there would have been approximately 250 total reported injuries per year. This document does not provide any of the numbers used to calculate the 3%; so regularly published reports from the NCAA were consulted.

The NCAA publishes yearly reports from the ISS for individual sports, such as baseball. The ISS yearly reports for baseball do not include a separate number of injuries to pitchers due to being hit by a batted ball. They include the number of injuries to pitchers, but these are not broken down by hazard pattern. They also include the number of injuries due to being hit by batted balls, but do not break these numbers down by player position. They do break down each category presented into injuries that occurred during games and injuries that occurred during practices. Additionally, the Baseball Reports are published by academic year while the percent of pitchers injured by a batted ball was reported simply by year. Reports from the three most recent academic years are presented in the following table.

Table 2.
Baseball Injuries
From NCAA ISS Baseball Reports

	1997-1998	1998-1999	1999-2000
Total Injuries	605	577	895
Practice Injuries	316	284	413
Game Injuries	289	293	482
Total Pitcher Injuries	156	137	232
Practice Injuries	100	78	131
Game Injuries	56	59	101
Total Batted Ball Injuries	46	49	71
Practice Injuries	19	17	19
Game Injuries	27	32	52

The annual average number of pitchers injured by batted balls (7.5) was clearly not 3 percent of the total injuries (605 total injuries in 1997-1998). However, 7.5 is close to 3% of 289, the total injuries that occurred during game play (as opposed to practice). So the 3% calculation appears to exclude injuries incurred during practice.

As can be seen above, more than half the reported injuries to pitchers occurred during practices: 100 out of 156, 78 out of 137, and 131 out of 232 for 1997-8, 1998-9 and 1999-2000, respectively. On the other hand, less than half the batted ball injuries occurred during practices: 19 out of 46, 17 out of 49, and 19 out of 71 for 1997-8, 1998-9 and 1999-2000, respectively. From the available data, it is impossible to know how many pitchers were injured by batted balls during practice, and whether this number is increasing or decreasing over any time period.

It seems rather arbitrary to report that the percentage of injuries to pitchers from batted balls is unchanging based on a calculation that excludes injuries incurred during practice. Practice is an integral part of participation in baseball at the collegiate level. Without information regarding injuries in practice, it seems premature to conclude that the number of pitchers injured by batted balls did not change.

Batted Ball Survey. The second source of information about injuries to pitchers in NCAA collegiate baseball was the Division I Baseball Injury Survey Pitcher Hit by a Batted Ball (Batted Ball Survey). In 1998, 1999, and 2000, the NCAA conducted a survey of pitchers hit by batted balls in its Division I member schools. This survey attempted to determine the number of times a pitcher was hit by a batted ball, regardless of whether the incident caused an injury as defined in the ISS.

The 1998 and 1999 data were compiled by Coach Bill Thurston of Amherst College who was the NCAA Baseball Rules Editor at the time. These summaries were included in the petition. Coach Thurston was not given access to the 2000 data. A CPSC staff request to the NCAA for all raw data and reports pertinent to the petition produced no data or reports from these studies[8]. The following discussion is based on CPSC staff analysis of the Thurston data included in the petition.

For 1998 and 1999 Coach Thurston listed each school reporting and the number of pitchers hit by batted balls at that school. There were 273 Division I schools in 1998 and 1999. The table on the following page summarizes the number of reporting schools and number of pitchers hit by batted balls.

[8] Letter from Elsa Kircher Cole, General Counsel, NCAA, to Mohammed Khan, CPSC, October 6, 2000.

Table 3.
NCAA Division I Baseball Injury Survey
Pitcher Hit by a Batted Ball
1998 and 1999

	1998	1999
Number of Reporting Schools	74	105
Percent of Total Division I Schools Reporting	27%	38%
Total Number of Pitchers Hit	173	273
Average Number of Pitchers Hit per School	2.3	2.6

Source: Thurston summary data provided in petition CP00-01

The petition contains data developed by Coach Thurston and others attempting to estimate the total number of pitchers hit in Division I schools in each year and then to determine whether there was an increase in injuries from 1998 to 1999. However, the percentage of schools reporting was very small, as shown above. In addition, reporting schools were those that chose to report and were not, therefore, a statistical sample. It cannot be assumed that this small number of voluntarily reporting schools is representative of all the NCAA Division I schools. It is not statistically valid to attempt to estimate the number of pitchers hit by batted balls in all NCAA Division I schools based on such a sample.

To determine whether there was a statistically significant difference in the average number of hits per school between 1998 and 1999, CPSC staff evaluated schools that reported in both years. There were 34 schools that reported in both 1998 and 1999. The average difference between the number of hits reported by a school in 1998 and the number reported in 1999 was 0.18, with a standard error of 0.35. This difference was not statistically significant (paired t-test[9] prob >T=0.6168[10]). However, caution should be used in interpreting this result. The difference was not significant in the 34 schools that reported both years. There were 239 additional Division I schools where it remains unknown whether more pitchers were hit in 1999 than in 1998.

Summary of NCAA Data. The NCAA data are also inconclusive as to whether injuries to pitchers from batted balls are increasing or decreasing. Reports of data from the ISS have apparently reported only game-related injuries to pitchers from batted balls and have not provided information on practice-related batted ball injuries to pitchers. Results from the batted ball survey indicated that 12 percent of NCAA Division I schools (34/273) showed no significant increase in injuries to pitchers between 1998 and 1999. However, this sample was not chosen in a manner that allows conclusions to be drawn about any other NCAA Division I schools.

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[9] The paired t-test evaluates pairs of data points; in this case, the number of hits reported by a given school in 1998 was paired with the number of hits the same school reported in 1999. This pairing helps to take into account differences between schools in the number of hits reported.

[10] The probability of a greater T is a measure of the probability that the observed difference might have happened by chance. Values range from 0 to 1.0. The smaller the value, the less likely that the result is due to chance. Values of less than 0.05 are generally considered to be statistically significant.

Data Submitted by the Petitioner. Appendix 1 contains a table summarizing the incidents included in the information submitted by the petitioner. Incidents labeled D1-D5 are deaths, incidents labeled I1-I31 are non-fatal injuries, incidents labeled P1-P29 are incidents which may be additional to the ones labeled I1-I31, but insufficient information was given to be able to determine whether these incidents were in fact different.

There were five deaths reported in the petition information. Three of the reported deaths were due to impact from a batted ball (D1-D3). One of these deaths (D3) was not found in the search of CPSC files (see below). Information contained in Easton's comments indicates that Easton's representatives attempted to confirm this death. They were able to find the original Gonzaga Bulletin article that reported this death as occurring to a Pony Leaguer in Utica, N.Y. However, the President of Pony League baseball said they have no Pony League in Utica and have no record of such a death. Little League also had no information about such a death. (Easton's comments, Tab 26) Two deaths (D4 and D5) were due to impact from a *thrown* ball and are illustrative of commotio cordis (chest impact death), which is one of the risks from ball impact.

Of the 31 incidents reported in the petition (I1-I31), one involved a thrown ball, rather than a batted ball. Of the additional 29 possible incidents (P1-P29), it was unclear in a number of cases whether the incident was due to a batted ball.

The petition also contained reports of 15 injuries that occurred to pitchers in Major League Baseball. However, these injuries would not be due to balls batted with non-wood bats.

International Injury Incidents. There were several reports of injuries that occurred in foreign countries in the petition. There was an injury in Australia in May 1998 where a pitcher was hit in the head by a ball (labeled A1 in Appendix 1). The Easton comments (Tab 26) state that this occurred in a professional baseball league in Australia.

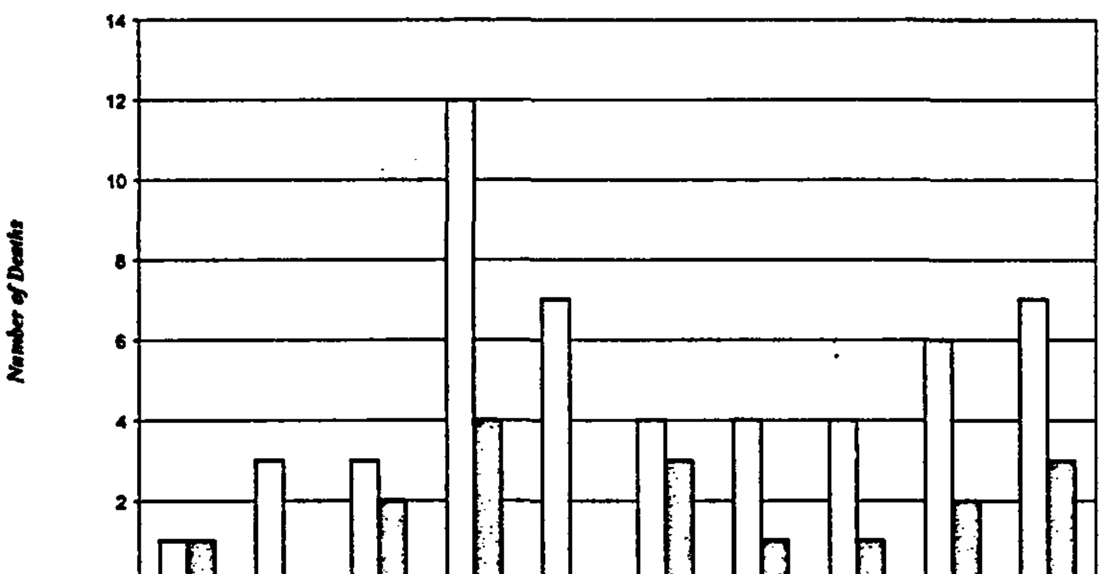
There were several mentions in the petition of deaths that occurred to baseball players in Japan (labeled J1-J7 in Appendix 1). A fax from the Japanese Information and Cultural Center of the Embassy of Japan included in the petition states that seven high school baseball players have died due to line drive hits with metal bats and that protective headgear will be required for pitchers during practice in the future. It also mentions a death in April of 2000 of a pitcher hit by a line drive in a practice game. It is unclear whether this death is included in the count of seven.

Summary of Petitioner's Data. Data provided by the petitioner support the assertion that injuries and deaths have occurred due to pitchers' being hit by balls batted with high performance non-wood bats. However, these data do not constitute a statistical sample or a complete count of all such injuries, and therefore cannot be used to determine whether any trends exist in the number or severity of these injuries.

CPSC Death Data. Appendix 2 contains a table summarizing the baseball- and softball-impact deaths of which CPSC staff is aware. Since January 1991, 51 such deaths have been reported to CPSC. These reports include all types of circumstances, not just organized baseball or softball activity such as games or practices. Of these 51 deaths, 17 were reported to have been due to batted-ball impact and include 2 of the 3 batted ball deaths included in the petition (the third death is the one that could not be confirmed according to the Easton comments). There were18 deaths related to thrown-ball impact. In 16 cases it was unknown whether the ball was thrown or batted. Of the 17 batted-ball impact deaths, 8 were reported to have involved non-wood bats, 2 involved *wood bats, and in 7 cases the type of bat was unknown.*

The following graph presents the number of deaths due to batted ball impact for each year in the 10-year period. The annual number of deaths was too small and the number varied too much from year to year for there to be any clear trend in the number of deaths, either increasing or decreasing.

Figure 5.
Deaths due to All Baseball Impacts
Compared to
Deaths due to Batted Ball Impacts
All Ages, All Circumstances
1991-2000*



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
All Ball Impacts	1	3	3	12	7	4	4	4	6	7
Batted Ball Impacts	1	0	2	4	0	3	1	1	2	3

Year

*Death certificate reporting is not yet complete for years after 1998.
Source: U.S. Consumer Product Safety Commission: Death Certificate Files, Incident and Potential Incident Files, In-Depth Investigations Files, and National Electronic Injury Surveillance System.

CONCLUSIONS

Based on currently available data, CPSC staff can neither confirm nor deny the petitioner's assertion that injuries to pitchers are increasing as non-wood bat performance characteristics change. Available information indicates that the overall numbers of injuries are declining and that the overall rate of injury is steady or declining. However, these data do not preclude the possibility that pitchers may be experiencing more injuries or more severe injuries from batted balls. The NEISS data are not sufficiently detailed to address this question. The NCAA ISS data are not reported fully enough to offer a definitive answer to the question.

Appendix 1
Incidents Reported by the Petitioner

ID	Date	Age/Sex	Th/Ba*	Injury	Description**
D1	June 22, 1997	17M	batted	head, frac skull	pitcher behind L-shaped net-batting practice-line drive ricocheted-brain death
D2	May 2000	14F	batted	head	hit in head while pitching batting practice-went home-nauseous-dizzy-toER
D3	Pre-Summer 1998	14?	batted	hit in temple	hit in temple - See Easton's Comments, Tab 26
D4	March 2000	15M	thrown	commotio cordis	thrown ball-practice scrimmage-running to second base-commotio cordis
D5	March 1998	17M	thrown	hit in chest	batter hit by pitched ball
I1	March 23, 1996	college	batted	facial inj, lost teeth	pitcher-five teeth shattered-62 stitches-0.29 seconds to react-video
I2	April 2, 1999	college	batted	frac skull	relief pitcher-ball hit with Louisville Slugger bat
I3	Feb 4, 1996	college	batted	frac cheek,brkn jaw	pitcher at Ariz State U-struck by line drive-later drafted by Major League team
I4	1987	college	batted	"felled"	pitcher felled by line drive
I5	1997	college	batted	cheekbone	pitcher hit by line drive
I6	May 3, 1999	high school	batted	brain injury	paralysis of left hand and fingers-80mph pitch off Easton C-core bat
I7	April 23	college	thrown	eye & socket	batter-intentional injury inflicted by pitcher of opposing team-as taught by coach
I8	Last June	12M	batted	frac skull, blood clot	12 yo son hit by batted ball while pitching
I9	May 30, 1997?	??	thrown	jaw	recreation league baserunner hit by thrown ball
I10	1992?	??	batted	teeth	recreation league pitcher teeth knocked out by a line drive while pitching
I11	April 1, 1999	17M	batted	skull frac, blood clot	hit in head by line drive while pitching in HS tournament
I12	March 5, 1999	college	batted	eye	college age pitcher hit in eye by a one-hop grounder off metal bat
I13	May 1999?	college	batted	head	relief pitcher struck on side of head by line drive off metal bat
I14	Feb-Mar 1996	??			Jack MacKay speech to Rules Committee
I15	Feb-Mar 1996	??			Jack MacKay speech to Rules Committee
I16	June 29, 1998	8-9M	batted	mouth	intermediate league (8-9 year olds) **firstbaseman**
I17	May 28, 2000	college	batted	jaw	two pitchers in regional series had jaws broken by line drives off non-wood bats
I18	May 26, 2000	college	batted	jaw	two pitchers in regional series had jaws broken by line drives off non-wood bats
I19	April 2000	16M	batted	chest	heavy bruising
I20	2000	11M	batted	head	pitcher hit by line drive
I21	?	collegeF	batted	knee	Baylor School UT-Chat pitcher-hit in exhibition game off Easton Red Line bat
I22	1998?	college	batted?	?	hit twice by line drives - not in head
I23	June 7, 1998	9M	batted	hit mound, mouth	9 yo pitcher hit in mouth by a line drive-bounced off mound - banned metal bats
I24	May 28, 1998	15M	batted	skull frac, brain bled	numbness on left side-Louisville Slugger Air Attack bat-line drive above rt temple
I25	May 1999	college	batted		"a couple of years ago, I took one off right arm, foot and ear"
I26	Two yrs ago	college	batted	head	hit by a line drive in the back of his head
I27	1996	college	batted	arm and leg	hit twice-100+ mph both times-150 lb **shortstop**
I28	April 1, 2000		batted	head	line drive off an aluminum bat - three skull fractures and broken artery
I29	April 13, 1998				
I30	April 1998	16m	batted	face	hit in face with line drive - 5 front teeth bonded together-lips injured
I31	Sept 1998	college fresh	batted	left temple	line drive off Easton Red Line bat - clocked at 105 -unconscious for a few secs

*Th/Ba indicates whether the ball was batted or thrown

**Player position, if known, is indicated in bold if other than pitcher

Appendix 1 (con't)
Incidents Reported by the Petitioner

ID	Date	Age/Sex	Th/Ba*	Injury	Description**
P1	1997	college	batted	broken jaw	pitcher
P2	1997	college	batted		pitcher
P3	Fall 1997	high school	batted	hit in chest	pitcher hit by batted ball
P4	Fall 1998	high school	batted	hit in chest	pitcher hit by batted ball
P5	May 28, 1998	15M	batted	temple	
P6	May 1998	college	batted		three pitchers in same tournament
P7	May 1998+H22	college	batted		three pitchers in same tournament
P8	May 1998	college	batted		three pitchers in same tournament-Fl State pitcher 5-inch gash-27 stitches
P9	May 12, 1997	HS Coach	batted?	head-brain dam	HS coach hit in head while pitching-now in wheelchair
P10	April 22, 1997	high school	batted?	head inj	pitcher hit over ear-brain bruise-ended season+prospective college ftball career
P11	Spring 1996	??	batted?	face	coach hit pitching indoor batting practice behind screen
P12	Spring 1995	??	batted?	temple	HS player struck while behind screen
P13	May 24, 1994	16	batted	chest	2nd baseman hit in chest by bounce grounder-cardiac arrest reversed
P14	Mid-March 1994	??	batted?	head	coach hit during batting practice - critical condition
P15	Just learned?!	college	batted	broken arm	pitcher-broken arm after hit by line drive with new NCAA yellow softball
P16	Feb 1998	college ump	batted	thigh	pitching umpire hit by line drive
P17	2000 season		batted		four injuries in their league from balls hit off the bats this year already
P18	2000 season		batted		four injuries in their league from balls hit off the bats this year already
P19	2000 season		batted		four injuries in their league from balls hit off the bats this year already
P20	2000 season		batted		four injuries in their league from balls hit off the bats this year already
P21	May 2000	HS	batted	head	two high school players hit in head by batted balls received fractured skulls
P22	May 2000	HS	batted	head	two high school players hit in head by batted balls received fractured skulls
P23	June 2000	12M	batted	jaw	on 46 ft mound-hit by a ball-pushed his maxilla 3/4 inch into his head
P24	1998 Season	HS			three pitchers injured this season by line drives off al bats
P25	1998 Season	HS			three pitchers injured this season by line drives off al bats
P26	1998 Season	HS			three pitchers injured this season by line drives off al bats
P27		college	batted	between eyes	rebounded over opponents' dugout and landed 90 feet away
P28	1998?	college	batted?	broken kneecap	Texas Tech hitter broke Kansas pitcher's kneecap-probably ending career
P29	1995	18F			lost my 18 year old daughter to a freak accident 3 yrs ago - baseball???
J1			batted		Japan - "pitchers' fatal accidents" - seven HS pitchers have died since 1974
J2			batted		Japan - "pitchers' fatal accidents" - seven HS pitchers have died since 1974
J3			batted		Japan - "pitchers' fatal accidents" - seven HS pitchers have died since 1974
J4			batted		Japan - "pitchers' fatal accidents" - seven HS pitchers have died since 1974
J5	(Nov 1997)	HS	batted		Japan - "pitchers' fatal accidents" - seven HS pitchers have died since 1974
J6	(Mar 1998)	HS	batted		Japan - "pitchers' fatal accidents" - seven HS pitchers have died since 1974
J7	(April 2000)		batted		Japan - "pitchers' fatal accidents" - seven HS pitchers have died since 1974
A1	May 1998	??	batted?	head	Australian league pitcher hit by ball - 11 metal plates and 22 screws

*Th/Ba indicates whether the ball was batted or thrown

**Player position, if known, is indicated in bold if other than pitcher

Appendix 2
Deaths Associated with Baseball- and Softball-Impact
CPSC Data Files 1991-1999

Date	Age		St	City	C/H	Th/Ba	Type	Narr
19910630	7	m	MD	Westernport	Ch	Ba	wood	struck in lower sternum by fouled ball, 15 ft from batter
19931027	3	m	FL	Boca Raton	Ch	Ba	al	commotio cordis - 10yo hit ball off al bat, caroomed off wall
19931231	5	m	AZ	Phoenix	Ch	Ba	unk	hit by batted ball - complication, blunt force injury, sternum
19940430	3	m	TX	GrandPrairie	Ch	Ba	al	struck in chest by a hard ball batted by brother - 20-25 ft - cc
19940720	11	m	LA	Marthaville	Ch	Ba	al	struck in chest by hard baseball batted from 35-40 ft
19940803	24	m	TX	Houston	Hd	Ba	unk	hit in head by batted ball which he pitched to his brother
19941029	5	m	FL	Orlando	Ch	Ba	al	hit in chest by ball batted from al softball bat by 31 yo
19960507	14	m	MS	Meridian	Ch	Ba	al?	fell after being hit w/batted softball in left chest
19960628	10	m	CA	Encino/LA	Hd	Ba	unk	hit in neck by batted solid rubber practice ball after one bounce
19960722	7	m	NM	Crownpoint	Ch	Ba	unk	victim pitched ball to friend who hit it, ball hit victim in chest-cc
19970623	17	m	CA	Glendale/LA	Hd	Ba	nonwd	hit by batted ball he had pitched during practice before game
19980604	6	m	IL	Lexington	Ch	Ba	al	struck in chest by foul ball, commotio cordis
19990812	9	f	IN	Michigan City	Hd	Ba	unk	hit in face w/batted ball she pitched, struck head on pavement
19990813	11	m	CA	PlayaDelRey	Hd	Ba	unk	struck in right temple by batted ball - died later in bed
20000506	4	m	CO	Thornton	Ch	Ba	al	hit by ball batted by bro's from al bat-?-conflicting stories
20000508	14	f	MS	Poplarville	Hd	Ba	unk	struck in head by softball batted with softball bat (she pitched)
20000611	7	m	NY	Centereach	Ch	Ba	wood	struck in chest by baseball batted to him by brother
19940413	9	m	CA	Glendale	Hd	Th	NA	hit in head with a pitched ball - died later of sudden cardiac
19940511	9	m	PA	Mohnton	Ch	Th	NA	batter hit by pitched ball - heart stopped - cc
19940605	12	m	MI	Allegan	Hd	Th	NA	struck in head by a baseball - thrown, not batted
19940628	12	m	NY	Brooklyn	Ch	Th	NA	struck in chest by baseball thrown by pitching machine
19940630	1	m	MO	Stewartsville	Ch	Th	NA	13mo hit in chest - walked in front of ball thrown by 5 yo sib
19950321	19	m	CA	Los Angeles	Hd	Th	NA	blunt head trauma when struck by a baseball from pitching machine
19950420	6	m	AL	Mobile	Ch	Th	NA	hit by thrown baseball in the chest, cardiomegaly?
19970402	16	m	OH	Ironton	Ch	Th	NA	struck in left chest by baseball while sliding into 3rd- fatal arrhythmia

Notes:
Th/Ba indicates whether the ball was thrown, batted, or unknown.
Types indicates whether the bat involved (if any) was wood, aluminum, unknown, or not applicable.

Appendix 2 (con't.)
Deaths Associated with Baseball- and Softball-Impact
CPSC Data Files 1991-1999

19970620	11	m	WA	Shelton	Hd	Th	NA	hit in head by ball while playing catch with friend
19980226	17	m	TX	Laredo	Ch	Th	NA	struck in chest by pitch while attempting a drag bunt
19980719	28	m	NV	Henderson	Hd	Th	NA	hit by softball during team game, fractured skull
19990423	14	m	GA	Thomson	Ch	Th	NA	stealing 3rd, stuck in chest by ball thrown by catcher - commotio cordis
19990525	13	m	OH	Columbus	Ch	Th	NA	struck by pitched baseball under left arm - LL game - commotio cordis
19990626	5	m	NE	Omaha	Ch	Th	NA	struck in chest by thrown ball from home to pitching mound
20000322	18	m	FL	Tallahassee	Hd	Th	NA	struck in head by thrown ball - running from 1st to 2nd
20000327	15	m	IN	Madison	Ch	Th	NA	rounding bases, struck above heart with thrown ball
20000423	35	m	FL	Jacksonville	Ch	Th	NA	struck in chest with softball - running from 2nd to 3rd
20000524	11	m	ID	Ammon	Hd	Th	NA	struck in neck with thrown baseball
19920426	23	m	PA	Salisbury	Hd	Unk	NA	struck on head with baseball - closed head injury
19920524	5	m	NY	Buffalo	Ch	Unk	NA	hit with baseball in left chest
19920529	10	m	PA	Eric	Hd	Unk	NA	playing catch - severe closed head injury - struck by baseball
19930722	10	m	MN	Ortonville	Hd	Unk	NA	hit in head with baseball brain herniation, epidural hematoma
19940609	9	m	FL	Miami	Hd	Unk	NA	struck in the head by a ball during a baseball game
19940609	39	m	TX	Texarkana	Hd	Unk	NA	softball hit right side of neck - strokes, carotid occlusion
19940720	11	m	LA	Shreveport	Ch	Unk	NA	hit in center of chest by baseball - fatal cardiac arrhythmia
19950101	4	m	AA	?	Ch	Unk	NA	blunt impact to chest causing sudden cardiac death/baseball
19950101	8	m	AA	?	Ch	Unk	NA	blunt impact to chest causing sudden cardiac death/baseball
19950101	9	m	AA	?	Ch	Unk	NA	blunt impact to chest causing sudden cardiac death/baseball
19950101	16	m	AA	?	Ch	Unk	NA	blunt impact to chest causing sudden cardiac death/baseball
19950101	18	m	AA	?	Ch	Unk	NA	blunt impact to chest causing sudden cardiac death/baseball
19960425	43	m	GA	Atlanta	Hd	Unk	NA	struck in head w/baseball seizure disorder, blunt force head trauma
19970504	16	m	CA	Torrance/LA	Hd	Unk	NA	playing baseball at HS field, blunt laryngeal trauma
19980729	84	f	PA	SalisburyTWF	Hd	Unk	NA	struck by softball - head injury - subdural hematoma
19990429	11	m	NJ	Perth Amboy	Ch	Unk	NA	struck in chest by baseball - cardiac concussion

Notes:
Th/Ba indicates whether the ball was thrown, batted, or unknown.
Types indicates whether the bat involved (if any) was wood, aluminum, unknown, or not applicable.

Tab D

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: August 13, 2001

TO : Erlinda M. Edwards,
Project Manager, Nonwood Baseball Bat Petition
Directorate for Engineering Sciences

THROUGH: Mary Ann Danello, Ph.D., Associate Executive Director, MAD
Directorate for Health Sciences
Lori E. Saltzman, M.S., Director, MKW for LES
Division of Health Sciences

FROM : Jason R. Goldsmith, Ph.D., Physiologist, JRG
Directorate for Health Sciences, x-1387

SUBJECT : Petition CP 00-1 (Nonwood Baseball Bats)

This memorandum has been prepared in response to Petition CP 00-1, which requests performance requirements for nonwood baseball bats.

The petition, written by Jack W. MacKay, a former consultant to Hillerich & Bradsby (manufacturer of Louisville Slugger bats), was prompted by the petitioner's belief that high-performance nonwood baseball bats (aluminum, composite, and graphite), some of which he helped develop, present an unreasonable danger and risk of injury to consumers due to their superior performance compared to traditional wood bats (i.e., larger sweet spot and greater ball exit speeds). In support of this claim, the petitioner provides frequency and severity of injury data from athletes being struck by baseballs hit by high-performance aluminum bats. The petition requests that the Commission set a national standard that would require that all nonwood baseball bats perform like wood bats and that all nonwood baseball bats that exceed the performance of wood baseball bats be recalled.

The Health Sciences' staff has assessed the types of injuries that may occur as a result of players being struck by a batted baseball or softball (independent of bat type) and provides the discussion below.

DISCUSSION:

The types of injury associated with being struck by a baseball or softball are mostly dependent on the type of ball (deforming vs. nondeforming), the kinetic energy and trajectory of the ball, and the anatomical region of the body that is impacted by the ball. The presence of protective equipment (designed to distribute the impact load over a greater surface area) at the point of impact can help reduce the risk of injury. Given that traditional softballs and baseballs do not deform significantly[1] the majority of the ball's impact energy will be transferred to the body part with which it collides. (Softer baseballs, which have recently been introduced, deform to a greater degree and consequently are expected to reduce the risk of injury). A basic law of physics predicts that small increases in the velocity with which a ball is hit will have dramatic effects on the kinetic energy of the ball, since kinetic energy is proportional to the square of the velocity ($KE = \frac{1}{2}mv^2$). Given the demonstrated dependency of injury severity on the kinetic energy of the object that impacts with a subject,[2,3] under similar conditions (i.e., if the type and trajectory of the ball, and body part impacted are held constant), it can generally be assumed that as the kinetic energy of the ball increases, so would the severity of injuries resulting from impact with the ball. However, the relative frequencies, types, and severities of injuries associated with players being struck by wood- vs. nonwood-batted balls cannot be assessed from the CPSC injury data, nor were they provided by the petitioner. Therefore, the discussion below will focus on the injuries that can occur as a result of being struck by a baseball or softball, independent of the bat type used to hit the ball.

Batted balls (baseballs and softballs) have the potential to produce a variety of injuries, ranging from bruises, abrasions, and lacerations, to more serious injuries, such as cardiac injury, head and neck injury, ocular and other facial trauma, and fractures. The more serious injuries require medical attention, and can have grave consequences. These injuries will be discussed in greater detail.

A recent CPSC staff report found that catastrophic injuries in baseball and softball occur most often when a player is struck in the chest or head. Of 88 baseball-related deaths in children ages 5-14 reported between 1973 and 1995, 68 were due to ball impact; 38 of the 68 were ball impacts to the chest, and 21 of the 68 were ball impacts to the head.[4] This report and others[5,6,7] illustrate that the severe injuries are not confined to the realms of collegiate or high school baseball and softball, but also occur in little league and other youth baseball game play. As one author has pointed out, certain characteristics of children may contribute to the risk of their being hit by a ball.[5] These include having less coordination, less experience, slower reaction times, and reduced ability to pitch accurately, as compared to older players. Whereas, the speed of the ball in youth baseball and softball is sufficient to cause serious injury, the speeds associated with high-school and collegiate-level play may be such that the more serious injuries occur more often. The increased strength and coordination possessed by high school and collegiate players may increase the likelihood of injury from a batted ball.

Ball impact with the chest is the most frequent cause of baseball-related fatality in players under age 15.[4] Young people may be particularly prone to fatal chest trauma because a young person's breastbone, located in the middle of the chest and close to the heart, has not yet matured and hardened, remaining thin and elastic. Thus, because it is more compliant, sudden impacts to the chest can damage the heart as it is compressed between the sternum and spine and/or alter its electrical rhythm.[5] Cardiac injuries from impact by a baseball or softball are of two types, contusions[8] and concussions.[5,7,9,10] In contusions, the cardiac tissue is structurally damaged by a severe force. This damage can lead to arrhythmias (any variation from the normal rhythm of the heart beat), which include various types of conduction disturbances and ventricular premature beats.[8] The arrhythmias of cardiac contusion are believed to develop gradually on the day of injury and to resolve over time, during which time exercise should be restricted. In most cases, a cardiac contusion injury is a benign disorder.

Cardiac concussions (referred to as commotio cordis in the medical literature) are functional injuries caused by impacts to the chest. Although they are without pathological findings, they can lead to sudden death from cardiac arrest.[9] It should be noted that such fatalities are rare events and that most mild chest impacts are uneventful. However, in symptomatic cardiac concussions, there is an immediate onset of symptoms that include collapse and loss of consciousness, lowered blood pressure, and immediate disturbance of rhythm and conduction, which makes commotio cordis both distinct from, and more dangerous than, cardiac contusion.[10] Due to the location of the excitable electrical heart tissues, nonpenetrating concussive blows to the heart can produce arrhythmias, including sinus tachycardia (high heart rate), conduction block (impairment of conduction in heart excitation, leading to delayed or absent beats), ventricular fibrillation (the asynchronous electrical activity of the ventricles, which results in uncoordinated ventricular contraction and ineffective cardiac output), and asystole (absence of heart beat).[5]

Clinical profiles of victims of commotio cordis[9] and animal model studies[11] suggest that ventricular fibrillation may be the cause of most fatal episodes of commotio cordis. The animal model studies also suggest that the arrhythmias of commotio cordis may only occur if the impact is delivered during a brief window of the cardiac cycle, when the heart is particularly vulnerable to stimulation (a 15 – 30 msec period during which the excitability of the heart is recovering from the last contraction and can be excited to contract asynchronously).[9] Autopsy findings show that commotio cordis occurs in the absence of structural cardiovascular disease or traumatic injury. The incidents are often caused by balls that did not appear to have sufficient energy to cause death.[9] For reasons that remain unknown, in most cases of commotio cordis, resuscitation efforts are not successful.[7,11]

Impact to the head can also have devastating consequences. Impacts to the skull have the potential to cause concussion (a trauma-induced alteration in mental status that may or may not be accompanied by a loss of consciousness), skull fractures, which can result in penetrating damage to the brain, and intracranial hemorrhaging, such as epidural, subdural and subarachnoid hematomas. Even with prompt medical attention, intracranial hemorrhaging has the potential to cause permanent brain injury, coma, or death.[12,13]

Facial injuries, including impact with the cheeks, nose, eyes, or teeth can also be severe. Fractures of the facial bones can result in nerve damage, brain injury, damage to the sinuses, painful movement of the jaw, and disfigurement. Impact to the nose, can lead to airway compromise and significant deformity.[5] Ball impact with the eye and orbit can cause a rupture of the globe, swelling of the eye, detached retina, hyphema (blood pooling between the cornea and iris), and blow-out fractures of the orbital floor (fracture of the thin-walled bone underlying the eye). These injuries can result in the loss of the eye (loss of binocular vision), blindness, or visual distortions.[5,14,15] Impact with the mouth can cause dislocation or fracture of the jaw, and/or the fracture, displacement (such as movement of the teeth up into the gums), or avulsion (partial or complete loss) of the teeth.

Injuries to the neck may also result from ball impact. The bones of the spinal column, including the neck bones, can be injured as a result of impact. Since the nerves that connect the brain to the rest of the body travel through these bones, damage to the nervous tissue is also possible. Injuries to the spinal cord have the potential to obliterate responsiveness and sensation for parts of the body below the site of injury. A blunt blow to the larynx can result in trauma that obstructs the airway, which can lead to hypoxia. Finally, there are also reported instances of traumatic internal carotid artery dissections as a result of direct impact of a ball with the neck,[16] which can lead to cerebral ischemia (deficiency of blood supply).

In addition to the injuries of the bones of the head, face, and spinal column already mentioned, injuries of other bones are also possible as a result of impact by a baseball or softball.

CONCLUSION:

The relative frequencies, types, and severities of injuries associated with players being struck by wood- vs. nonwood-batted balls cannot be assessed from the CPSC injury databases, nor was this information provided by the petitioner. Nonetheless, batted balls, both baseball and softball, have the capability to produce a variety of injuries, the most severe of which may lead to death. If the properties of a nonwood baseball bat enable the user to hit a pitched ball more consistently than is possible with a wood bat, the likelihood of someone being hit by the batted ball would be expected to increase. If the ball is also hit with greater velocity using a nonwood baseball bat, its increased kinetic energy would be expected to produce more severe injuries.

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Tab E

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

MEMORANDUM

August 14, 2001

To: Erlinda M. Edwards
Project Manager, Nonwood Baseball Bats Petition CP 00-1
Division of Electrical Engineering, Directorate for Engineering Sciences

Through: Hugh M. McLaurin
Associate Executive Director
Directorate for Engineering Sciences

Through: Robert B. Ochsman, Ph.D.
Director, Division of Human Factors

From: Timothy P. Smith
Engineering Psychologist, Division of Human Factors

Subject: Human Factors Assessment for Petition CP 00–1,
Petition Requesting Performance Requirements for Nonwood Baseball Bats

Introduction

The U.S. Consumer Product Safety Commission (CPSC) received a petition (CP 00-1) from J.W. MacKay, Jr. requesting that CPSC issue a rule requiring that all nonwood baseball bats perform like wood bats. The petitioner asserts that these high-performance nonwood bats achieve a higher exit speed from the bat, and that the pitcher does not have sufficient time to react to a ball batted towards him. This memorandum discusses the response times of pitchers to batted balls.

Discussion: Pitcher Response Time

In the game of baseball, the pitcher's distance to the batter is shorter than for any other infielder in front of the catcher, giving the pitcher the least amount of time in which to respond to a batted ball. Staff from the Division of Human Factors (HF) has reviewed scientific literature on human response times to estimate the time a pitcher requires to avoid being struck by a batted baseball that is on a collision course with him. The focus of this memo is on men's college baseball players, who are generally more capable than less skilled players of generating higher batted-ball speeds, and thus shorter flight times to which a pitcher must respond. In general, the phrases "reaction time" and "response time" are used interchangeably in this memorandum.

Dr. Brandt's Response Time Study

Scientists have conducted numerous studies on human response times to various stimuli, yet the results of most studies are not directly applicable to the situation encountered by pitchers who find themselves in the path of a batted baseball. Perhaps the most pertinent study is one conducted by Dr. Richard Brandt, a professor of physics at New York University, in which baseballs were randomly shot at subjects who attempted to deflect the balls with their gloves before being struck by them. Subjects included men's college baseball players, and although the sample size for this group was small (N = 8) the results provide a good first estimate of their response times to this situation. The maximum time at which men's college baseball players were unable to deflect the ball in time was 0.368 seconds, meaning all balls with flight times greater than this were successfully deflected by all men's college baseball players (Brandt, 1998). When failure rate was plotted versus flight time, the data for this group fit a straight line. Using the equation for this line, one can estimate that about 95% of players could respond in about 0.37 seconds, 90% in 0.35 seconds, and 50% in 0.23 seconds.[1] Dr. Brandt concluded that 0.38 seconds was a "very conservative safe response time for college baseball players" (Brandt, 1998). High school and youth baseball players showed slightly longer response times, as one would expect from younger and less experienced players, but the sample sizes in these groups were exceptionally small (high school N = 2, youth N = 1) and cannot be relied on to represent those groups as a whole.

Dr. Brandt performed additional tests on three college players with pitching experience. Unlike previous tests in which the subject simply stood and waited for a ball to be propelled at him, these required the subject to first perform a pitching motion. After a 0.4-second[2] delay, a ball was then propelled at the subject. Following 20 repetitions for each of the three pitchers, Dr. Brandt found no observed difference in the time needed to deflect balls. This is unusual in that research on reaction times has consistently found decreases in response times when one is cued or has knowledge that a stimulus is about to occur. The comparable response times between the standing versus pitching conditions may be due to a more off-balance position of the pitcher at the time of the required response, which might increase movement times to such a degree that they cancel out the decreased reaction times. However, this is merely speculation and the results could just as easily be due to the tests' small sample size.

Dr. Brandt's Study Versus Real-Life

In Dr. Brandt's study, like most studies of human response times, the subjects were always alert and concentrating on the task. One could argue that it is perfectly reasonable to expect the same of college baseball pitchers, especially immediately after completing a pitch. However, certain features of Dr. Brandt's study may limit the extent to which the results can be directly applied to the real-life situation of pitchers responding to batted balls. Dr. Brandt measured response times by varying the distance between the player and the point at which the ball is launched while maintaining a constant batted-ball speed. This is opposite the real-life situation in which the

[1] The equation for this line is $P = 120.6 - 312T$, where P is the hit percentage (i.e., failed to deflect the ball) and T is the flight time in seconds. The hit percentage ranged from 0.0% to 76.7%, therefore extrapolations of the data outside this range (e.g., attempting to calculate the flight time resulting in 95% of pitchers being struck) may be inaccurate.

[2] 0.4 seconds was selected based on the typical flight time of a pitched fastball.

pitcher is always the same distance from the batter, and the balls are batted at variable speeds. Although Dr. Brandt's method does measure the response time of the subject, it is unclear what effect, if any, this difference in conditions has on the response times of subjects.

Dr. Brandt's study required subjects to look for a single stimulus (i.e., a ball approaching them) and perform a single predetermined response, (i.e., deflect the ball with his or her glove). This one-stimulus one-response study is consistent with measurements of simple visual response times, and the results of this study seem consistent with this given that college pitchers averaged response times of around ¼ second. During an actual baseball game, however, a pitcher must identify and process multiple stimuli (i.e., swing and miss, swing and hit away from the pitcher, and swing and hit towards the pitcher) and only respond to a single one of those stimuli (i.e., swing and hit towards the pitcher). Hence, the real-life situation more closely resembles a disjunctive response—sometimes referred to as a Donders C reaction—which is consistently longer in duration than a similar simple response due to the cognitive processing involved.

Disjunctive response times assume the participant is making a conscious decision to respond to the appropriate stimulus. Some responses by athletes are virtually indistinguishable from conditioned reflexes, in which a response occurs without conscious control (Karpovich & Sinning, 1971; Kroemer & Grandjean, 1997). However, this requires extensive training and practice of the particular sequence of movements involved in the response, and it seems unlikely that college pitchers have trained deflection or avoidance responses to the degree required for this to occur. Due to the potential for physical harm, one could argue that a pitcher's deflection or avoidance of a ball could be an unconscious reflex acting as an automatic protective mechanism, much like the reflexive blinking of the eyelids during an unexpected movement towards the eyes (Kroemer & Grandjean, 1997). Since reflexes of this type are not consciously directed, they do not have the additional cognitive processing time associated with disjunctive responses. So if this were the case, a pitcher's real-life responses could be very similar in duration to the simple responses encountered in Dr. Brandt's study. Nevertheless, without additional data on the potential relationship between real-life pitcher response times and protective reflexes, it seems reasonable to assume that real-life responses are somewhat longer than those found in Dr. Brandt's study.

Dr. Brandt notes that under real-life game conditions pitchers are alerted to possible bat-ball contact by the batter's swinging of the bat, and that this tends to decrease response times. Cueing has been found to decrease response times slightly when it always occurs at a fixed, short interval prior to the stimulus, thereby making the stimulus highly predictable (Boff & Lincoln, 1988; Regan, 1997). However, the majority of bat swings do not make contact with the ball, let alone direct the ball's flight towards the pitcher. It has been found that lower probability stimuli will tend to increase response times (Wickens & Carswell, 1997), and the probability that a swing of a bat will both strike a ball and direct that ball towards the pitcher during a typical game appears to be very low. So while a swinging bat may alert a pitcher to a *possible* need to respond, it is unlikely to reduce response times by a significant amount, if at all, since it is not a good predictor of the stimulus to which the pitcher must respond. Furthermore, the assumption that bat swings will shorten pitchers' response times ignores the results of Dr. Brandt's follow-up testing, in which there was no observed decrease in response times despite the fact that pitchers knew a ball would be fired soon upon completion of a pitch. In fact, since the firing of the ball during the follow-up testing occurred predictably at approximately the same interval following *every* pitching motion, it more closely represents ideal cueing than the swinging of a bat in a real-life situation. Given that this close-to-ideal cueing condition resulted in no observed decrease in response times, HF staff believes that the swinging of a bat is likely to result in response times that are actually somewhat longer than those found in Dr. Brandt's study.

Response times also depend on the discriminability of alternative stimuli; as the alternatives become more similar, an individual's response time generally increases (Boff & Lincoln, 1988). Study participants were not directly exposed to this problem, yet it seems highly likely that a batted ball that is directed towards the pitcher would appear quite similar to one that is directed away from the pitcher. HF staff believes that the visual similarity between these two stimuli is likely to increase the real-life response time of a pitcher. Other environmental and physiological factors, such as glare, baseball-background contrast, and miscellaneous visual and auditory distractors are also likely to increase pitcher response times. Lastly, fatigue has been found to increase response time (Boff & Lincoln, 1988; Karpovich & Sinning, 1971), most likely due to diminished motor control and coordination (Dechovitz, Schutz, & Sadosky, 1974). Therefore, a pitcher's response time will tend to increase during the course of a game.

Estimated Real-Life Response Times

The results of Dr. Brandt's study indicate that 95% of men's college pitchers could respond to a propelled baseball in about 0.37 seconds, and Dr. Brandt considered 0.38 seconds to be a safe response time. If a pitcher's response to a baseball that is batted towards him is more like a protective reflex than a conscious decision to act, HF staff believes that 0.38 seconds may be a reasonable estimate of the 95th percentile response time for men's collegiate baseball pitchers before fatigue starts to set in. However, there is no evidence that this is the case, and it seems likely that an effective deflection response would require more time than this for reasons discussed earlier. The petitioner states several times that 0.4 seconds is commonly recognized as the amount of time required by a pitcher to defend his position. Without data on real-life responses to batted baseballs, HF staff believes that 0.4 seconds is a reasonable, albeit rough estimate of the 95th percentile response time for alert, unfatigued, men's collegiate baseball pitchers who prepare themselves for a batted ball immediately following their pitching motion. This value will necessarily increase under less-than-ideal conditions and as the pitcher becomes fatigued.

Conclusions

HF staff estimates that 0.38 seconds is the minimum flight time required to ensure that around 95% of pitchers will be able to deflect a batted ball under ideal conditions. However, 0.4 seconds or more may be required under real-life conditions, especially as the pitcher becomes fatigued. Based on the stride of the pitcher, the posture of the pitcher following a pitch, and the location of bat-ball contact with respect to home plate, the distance between the pitcher and the point of bat-ball contact is estimated to be 49 ½ to 54 feet.[3] HF staff estimates that a baseball would require

[3] The distance from the pitching rubber to the back of home plate is 60 ½ feet. According to Brancazio (1984), Watts & Bahill (2000), and Exhibit 34-A of the Petition, a pitcher is typically 5 to 8 feet closer to the batter upon completion of a pitch due to his stride and final posture. The point of bat-ball contact is estimated to be 1 ½ to 3 feet in front of the back tip of home plate (Exhibit 34-A of the Petition; Watts & Bahill, 2000). Based on these estimates,

an initial batted-ball speed of about 101 to 102 miles per hour to travel 54 feet in 0.38 seconds, and an initial batted-ball speed of about 93 miles per hour to travel 49 ½ feet in the same amount of time.[4] Therefore, HF staff expects that at least 5% of men's college pitchers would be unable to respond to batted balls that exceed 102 miles per hour.

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HF staff believes the distance between the point of bat-ball contact and the pitcher upon completion of a pitch is between 49 ½ and 54 feet in length. Brandt's (1998) estimate of 54 feet also falls within this range.

[4] A flight time of 0.38 seconds over a distance of 54 feet and 49 ½ feet would correspond to average ball speeds of about 97 miles per hour and 89 miles per hour, respectively. According to Adair (1994) a pitched baseball loses speed due to air resistance at the rate of about 1 mile per hour every 7 feet, and according to Watts & Bahill (2000) a pitched baseball loses about 10% of its initial speed during its flight to the plate. Assuming a batted baseball loses speed due to air resistance at the same rate as a pitched baseball, the initial batted ball speeds would be approximately 101 to 102 miles per hour and 93 miles per hour, respectively.

Tab F

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: August 1, 2001

TO : Hugh M. McLaurin
Associate Executive Director
Directorate for Engineering Sciences

FROM : Nicholas V. Marchica NVM
Director
Division of Mechanical Engineering

Erlinda M. Edwards
Acting Director
Division of Electrical Engineering

SUBJECT : Petition CP 00-1, Non-Wood Baseball Bats

A. Product Description

The baseball bat has undergone a number of changes since baseball was introduced over 100 years ago. Originally, the game of baseball was commonly played with heavy hickory "sticks" that weighed up to 42 oz. White Ash was later discovered to be a superior and less dense wood and, with this, baseball bats were made lighter and with larger barrels and "sweet spots." (The "barrel" is the term for the large-diameter portion of the bat. The barrel is considered to be the primary aspect of a bat, since it is the area that is intended to make contact with the baseball. The "sweet spot" is the region of the barrel that provides the greatest transfer of energy to the ball and is generally within six inches from the barrel end.) For a given bat length, a lighter bat enables a batter to generate faster swings. A larger barrel also affords improved batting performance since the contact surface area is increased.

By 1970, bat manufacturers were producing low-grade aluminum bats that were lighter and stronger than ash bats. These bats became popular because they were comparable in price to wood bats and offered advantages of increased strength and durability. Today, non-wood bats represent the majority of bats in use.

B. Bat Performance

Advances in metallurgy and fabrication processes, particularly since the mid 1990s, have had a significant impact on aluminum baseball bat performance. By tailoring the compositions of the aluminum alloys used for bat construction, manufacturers can control the bat's overall weight and weight distribution, as well as influence the behavior of a bat when the bat strikes a pitched ball.

Manufacturers are able to enhance the performance of a bat by adjusting the bat's moment of inertia (MOI). MOI is a scientific term for quantifying an object's resistance to angular acceleration that produces rotation about a certain point or axis. The lower a bat's MOI, the easier it is to swing. A bat's MOI is a function of the bat's total weight and length and how the weight is distributed along the length of the bat. Reducing the total weight of the bat lowers the bat's MOI. Decreasing the distance between the bat's center of mass (the point location of an object where all of its weight can be considered to be concentrated) and the point of rotation also lowers the bat's MOI.

A bat's mechanical properties can be engineered to harness the kinetic energy involved in a bat-ball collision to enhance the ball exit speed by propelling the ball off the bat. When a pitched ball contacts a bat, the barrel "flexes" and the ball deforms around the barrel. The ball is then propelled off the bat as the flexed contact area of the barrel springs back into its original position. This is known as the "trampoline" effect.

When a non-wood bat strikes a ball, it can trampoline in two different modes. The bat can develop a local deformation that corresponds to the point of impact and conforms to the ball's spherical geometry. The bat can also flex in a hoop mode. This pertains to the change in the barrel's roundness that can occur at impact. The hoop mode is evident when the barrel, which appears as a circle when viewed from the end and prior to contact, becomes distorted and takes on an elliptical profile at impact. The higher the bat swing speed (or total bat-ball collision speed), the more significant the trampoline effect becomes. This is true to some upper limit that is established by the design of the bat. With a given aluminum alloy, the trampoline effect becomes more appreciable as the wall thickness of the barrel is decreased. (However, decreasing the wall thickness also makes the bat less durable.)

In a study of baseball bat performance, the performance of two wood and five aluminum baseball bats was studied with 19 players in a batting cage facility.[1] The 19 players included nine professional players, six current NCAA college players, and four high school players. The study measured a number of variables including ball inbound velocity (ranging from 48 mph to 66 mph), bat swing speed, bat impact speed, impact location, and batted ball speed. The study concluded that, overall, aluminum bats outperformed wood bats. Of the five aluminum bat models studied, one model outperformed all other models, and one bat was most similar to the wood bats (including a comparison of batted ball speed and percentage of pitched balls hit).

The two wood bats included in the study were each 34 inches long with a weight of 31 oz., or a -3 weight/length difference; the wood bats both had barrel diameters of 2-1/2 inches. The aluminum bat which was reportedly most similar in performance to the wood bats was 33 inches long with a weight of 30 oz., or a -3 weight/length difference; this bat had a barrel diameter of 2-5/8 inches. For the other aluminum bats, one had a weight/length difference of –4 and a barrel diameter of 2-5/8, and three had a weight/length difference of –5 and barrel diameters of 2-3/4 inches.

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[1] Crisco JJ, Greenwald RM, Penna LH (National Institute for Sports Science and Safety), "Baseball Bat Performance: A Batting Cage Study" (Draft Report July 14, 1999) [On line]. Available: www.nisss.org. This work was funded by the Sporting Good Manufacturers Association.

C. Voluntary Standards

The American Society for Testing and Materials (ASTM) F1881-98, "Standard Test Method for Measuring Baseball Bat Performance Factor," specifies a method for calculating batted ball speeds based upon certain bat performance measurements. Use of this test method can provide sports governing bodies a means to compare the anticipated batted-ball speed, thus batted-ball distance for the purposes of controlling the game and safety. The standard specifies a method to measure the Coefficient of Restitution (COR), which is an expression for the efficiency of energy transfer between colliding objects (bat and ball) and provides a mathematical relationship that can be used to predict batted ball speeds.

The standard calls for a ball of known COR to be propelled (at speeds between 57.95 and 62.04 miles per hour) from an air-powered cannon onto a stationary test bat. The test bat is held in place by a fixture that allows the bat to experience rotational motion when the ball impacts it. The ball's inbound speed and the bat's resulting rebound speed are recorded and, in conjunction with the inertial properties of the bat and ball, used to determine the bat-ball COR. Under the Amateur Softball Association's (ASA) certification program, new aluminum bats are tested in accordance with this procedure and limited to a (calculated) batted ball speed of 85.2 mph.

For National Collegiate Athletic Association (NCAA) play, baseball bats are certified to criteria established by the NCAA Executive Committee for baseball. The most recent bat performance criteria were effective for regular-season and championship play beginning January 1, 2000. The NCAA certification criteria include requirements for size, weight, and a maximum ball exit speed based upon a specified bat swing speed and ball input speed. Industry sources say this was done primarily to maintain the balance of the game between offense and defense, not to lower the incidence of ball impact injuries.

In testing to the NCAA protocol, testing is computer controlled and programmed to test all bats at the same target speed, regardless of differences in test bat weight, length, or moment of inertia. The NCAA test protocol includes the use of a specially designed machine, the Baum Hitting Machine (BHM). The BHM allows laboratory testing that more closely approaches the dynamics of an actual batter's swing of the bat compared to the ASTM method. The test bat is positioned in the machine and swung at a target speed. The target speed for the bat is defined as the magnitude of the linear velocity of a point on the test bat that is six inches from the barrel end. The BHM simultaneously accelerates a baseball to its target speed and collides the test bat and ball. The protocol specifies 66 mph and 70 mph for the bat and ball target speeds, respectively.

The NCAA certification criteria are the following:

1. "-3" Length/Weight difference. *This means that, for a given bat, its weight expressed in ounces (without any grip material) must not be less than three units of the bat's length expressed in inches; e.g., a 33-inch bat must not weigh less than 30 ounces.*

2. The bat's barrel diameter must not exceed 2.626 inches.

3. A certified "bat ring" with an inner diameter of 2.657 inches must pass over the bat after each of five test collisions.

4. The Ball Exit Speed Ratio (BESR) resulting from the average of five consecutive valid hits at the maximum velocity location must not exceed 0.728; this corresponds to a ball exit speed of 97 mph. The maximum BESR criterion is based on the ball exit velocity that is achievable at the specified target speeds with a 34/31 wood Baum-brand bat. The 34/31 class was specified since it was believed to represent a popular length/weight combination in the sport.

The BESR is a mathematical relationship between the recorded bat and ball velocities and is defined as:

$$BESR = [v' - (V - v) / 2] / (V + v)$$

where: V = bat speed at the 6 inch point
v = ball entry speed, and
v' = ball rebound or "exit speed"

Since the actual point of impact may not exactly correspond to the 6-inch location, the speed of the bat at this location is recorded and adjusted accordingly to reflect the bat input speed at the 6-inch location. The BESR is calculated after five valid collisions to determine if the test bat meets the certification performance requirement for maximum ball exit speed.

The ES staff does not know the derivation of the BESR equation -- whether it is based on empirical data or was theoretically derived. In the BESR equation, the bat and ball velocities are equally numerically weighted. However, since bats physically weigh more than balls, the BESR may not accurately reflect actual field experience. The Baum Research & Development Co., Inc. (BRDC) demonstrated that the entry velocity of the ball is not an equal contender in influencing the ball exit velocity. The BRDC showed that, by maintaining a constant total collision speed (ball entry velocity + bat swing velocity) by varying the ball and bat speeds, the ball exit velocity increases with increasing bat velocity.

The NCAA, in its response to the CPSC solicitation for comments, indicated that in June 2000 its Baseball Research Panel recommended changes to the certification protocol to make non-wood bats perform more like wood bats. The recommendation included effecting a minimum MOI provision and a "sliding scale" for swing speeds to account for different length and weight combinations. The sliding scale rule was approved in July 2000 to be effective January 1, 2003. Additionally, the ASTM Baseball Subcommittee, on February 8, 2001, issued a proposal for changes to its bat performance test to include faster ball input speeds.

Discussion/Conclusions

There are standards and test protocols in place that governing bodies can use to regulate bat and ball performance to control a baseball game and to maintain balance between offense and defense. The NCAA has criteria for bats, and they have taken additional steps which will make non-wood bats perform more like wood bats.

A study of bat performance showed that aluminum bats generally outperformed wood bats. Based on this study, one aluminum bat model meeting the current NCAA criteria for weight/length difference and barrel diameter performed similarly to the wood bats in the study. The other aluminum bats, which outperformed the wood bats, did not meet the NCAA criteria – they did not meet the "-3" length/weight difference required for NCAA certification, and three of the four bats violated the maximum barrel diameter requirement.

Studies indicate that collegiate-level bat/ball collision speeds can exceed the NCAA test protocol. However, data comparing ball exit speeds for balls hit by wood bats and balls hit by NCAA-compliant non-wood bats at collision speeds that represent those of actual NCAA level play are not available. This would provide information in assessing a potential added hazard associated with non-wood bats at collegiate-level play. Also, the corresponding time required for the ball to reach the pitcher could be calculated and compared to estimated safe reaction times for pitchers and the requirements for the NCAA standard.

Tab G

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: August 1, 2001

TO : Hugh M. McLaurin
Associate Executive Director
Directorate for Engineering Sciences

FROM : Erlinda M. Edwards
Acting Director
Division of Electrical Engineering

SUBJECT : Staff Analysis of Public Comments

On June 15, 2000, the Commission published a request in the *Federal Register* for public comments regarding this petition (*Federal Register*/Vol. 65. No. 116). Twelve comments were submitted by or on behalf of individual consumers, baseball equipment manufacturers, and organizations associated with baseball (Little League Baseball Incorporated and the NCAA). Included with many of the comments were supporting data such as newspaper articles reporting injuries due to batted balls, copies of various studies and injury data/surveys. Three of the comments were from a single commenter, who provided supplementary data for staff consideration.

The primary safety issues addressed in the comments, and the staff analyses of these comments, are presented below.

Unreasonable Risk

Comment: Five commenters expressed concern regarding the seriousness of injuries that can occur using high performance bats or that such bats present an unreasonable risk of injury. The other five commenters presented injury and other data to demonstrate that baseball is a relatively safe sport.

Response: Batted balls have the capability to produce a variety of injuries, the most severe of which may lead to death. Staff is aware of at least 17 deaths due to batted ball impact from January 1991 to January 2001. Of these, 8 were reported to have involved non-wood bats, 2 involved wood bats, and in 7 cases the type of bat was unknown.

If a user is able to hit a pitched ball with greater velocity using a non-wood bat, its increased kinetic energy would be expected to produce more severe injuries. However, the relative frequencies, types and severity of injuries associated with players being struck by wood vs. non-wood bats cannot be assessed from the CPSC injury databases nor was the information provided by the petitioner.

The available statistical data can neither confirm nor refute the assertion that the risk of injury to pitchers and infielders has become more prevalent. Available information indicates that overall the numbers of injuries are declining and that the overall rate of injury is steady or declining.

Bat Performance

Comment: Two commenters referenced research conducted by Dr. J.J. Crisco on bat performance, which indicates that aluminum bats outperform wood bats. In addition, several commenters noted that the NCAA has already taken steps to reduce the performance of aluminum bats and that these requirements have also been adopted by the National Federation of High School Sports.

The NCAA stated, "Although there had not been a significant increase in injury rates attributed to the use of non-wood bats over this time period [the past decade], there was a growing concern that the balance between offense and defense in the game was skewed with a great increase in home runs and severe diminishment in fielding. Additionally, three years ago anecdotal and other information brought to the attention of the NCAA by baseball coaches, athletics administrators, student-athletes and their parents indicated that the non-wood bat's apparent substantial outperformance of its wood counterpart might be increasing risk to players as well as affecting the integrity of the game. These concerns led the NCAA to take steps to diminish the power of the non-wood bat."

Response: The most recent bat performance criteria for NCAA regular-season and championship play were effective beginning January 1, 2000. The NCAA certification criteria include a requirement for a maximum weight/length difference of –3, a barrel diameter no greater than 2.626 inches, and a maximum ball exit speed of 97 mph (based upon a specified bat swing speed and ball input speed). In addition, the NCAA indicated that in June 2000 its Baseball Research Panel recommended changes to the certification protocol to make non-wood bats perform more like wood bats. The recommendation included effecting a "sliding scale" for swing speeds to account for different length and weight combinations. This rule was approved in July 2000 to be effective January 1, 2003.

In a study of baseball bat performance (the Crisco study that was referenced), the study showed that aluminum bats generally outperformed wood bats. Based on this study, one aluminum bat model meeting the current NCAA criteria for weight/length difference and barrel diameter performed similarly to the wood bats in the study. The other aluminum bats, which outperformed the wood bats, did not meet the NCAA criteria.

Pitcher Response Times

Comment: A few commenters quoted research conducted by Dr. Richard Brandt on pitcher response times – some to demonstrate that pitchers would have insufficient time to respond to a batted ball, and some to demonstrate that pitchers would have sufficient time to respond to a batted ball.

Response: The pitcher's distance to the batter is shorter than for any other infielder, giving the pitcher the least amount of time in which to respond to a batted ball. The focus of the human factors analysis was on men's college baseball players, who are generally more capable than less skilled players of generating high batted-ball speeds and, thus, shorter flight times to which a pitcher must respond.

Based upon Dr. Brandt's study, the staff estimates that the minimum reaction time for 95 percent of college pitchers to safely avoid being struck by a batted ball under ideal conditions is 0.38 seconds and that 0.40 seconds or more is needed for real-life conditions. Response times would be expected to increase during the course of a game.

Studies indicate that collegiate-level bat/ball collision speeds can exceed the NCAA test protocol. However, data comparing ball exit speeds for balls hit by wood bats and balls hit by NCAA-compliant non-wood bats at collision speeds that represent those of actual collegiate-level play are not available. This would provide information in assessing a potential added hazard associated with non-wood bats at collegiate-level play. Also, the corresponding time required for the ball to reach the pitcher could be calculated and compared to estimated safe reaction times for pitchers and the requirements for the NCAA standard.

Comment: One commenter stated that there are many factors that may contribute to injury risks from batted balls. Among those factors is the color of the backdrop behind the batter.

Response: Staff agrees that the color of the backdrop behind the batter can contribute to the injury risk from batted balls, as this affects the pitcher's ability to distinguish the ball from the background. Poor contrast between the baseball and backdrop is likely to increase a pitcher's response time and may make him more susceptible to being struck by a ball batted towards him.

__**Options to Address Injuries**__

Comment: One commenter stated that another factor which may contribute to injury risks from batted balls is the hardness/softness of the ball. Another commenter suggested that there are other options to address injuries associated with batted ball impact, such as the use of lower-risk-of-injury baseballs and head/facial protective equipment.

Response: A 1996 CPSC study of baseball injuries[1] concluded, in part, that softer-than-standard baseballs and softballs, which have a softer, spongier core than most standard baseballs and softballs, can reduce ball impact injury. Face guards that attach to batting helmets and protect the face could reduce injuries to batters [from thrown balls].

[1] Kyle SB. Youth baseball protective equipment project final report. U.S. Consumer Product Safety Commission. Washington, DC, 1996.